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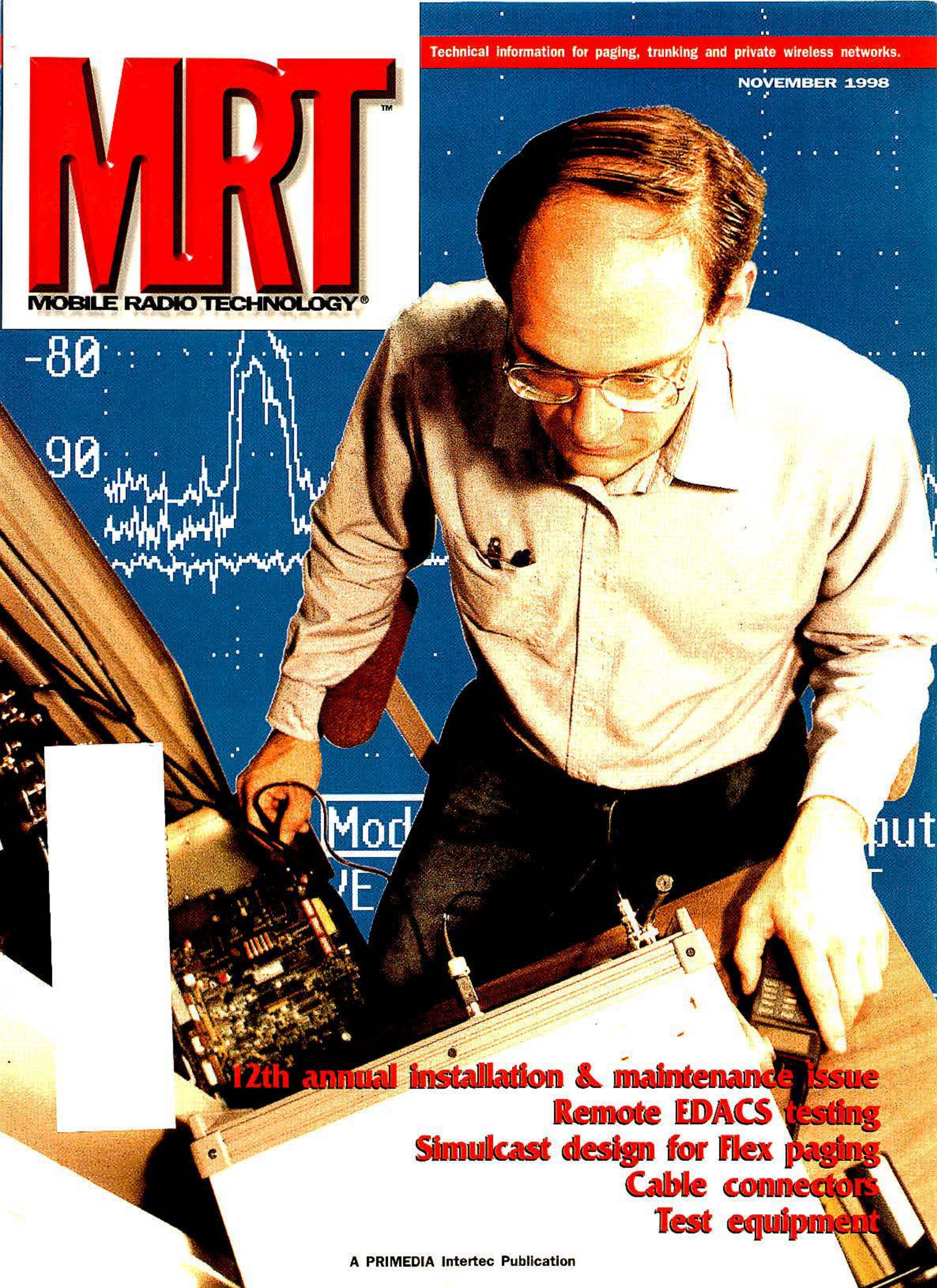
NOVEMBER 1998



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Technical information for paging, trunking and private wireless networks.

contents

November 1998

On the cover: Test equipment relies increasingly on software to provide a range of procedures, such as diagnosing trunking control sites. *Photo by D.A. Keckler; cover design by Scott Dolash, associate art director.* See story on page 16.

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Tainted spectrum

MRT received a fax at the end of September that read, "News Flash! FCC enforcement staff invades local Denver radio two-way dealers en masse. Twenty to 30 inspectors appeared unannounced last week to inspect 900MHz business systems..." Depending on how you look at it—*invades* or *inspects*—it looks like the FCC is up to something in Colorado.

What *is* the FCC doing? According to Denver operators and the Industrial Telecommunications Association (ITA), some radio dealers are committing illegal acts.

Here's an example of what's happening: A private business with 10 employees applies for 10 channels for private company use. The FCC grants the license (although a business is only eligible for one channel per 70 mobiles—the FCC doesn't necessarily verify the need). A radio dealer connects with the private company, takes some of its not-for-profit channels (900MHz YU spectrum) and sells airtime to end-users. The private company obtains the license under false pretenses, and the dealer uses the not-for-profit license to make a profit. Meanwhile, other dealers pay nearly $1 million in an FCC auction for 900MHz channels for commercial use, and, accordingly, charge their customers higher rates.

This has been happening for a while, and dealers are bold enough that almost everyone is talking about it. Local operators are talking, ITA is talking and manufacturers' representatives are talking. The FCC is not. It had no comment about the situation in Denver.

The number of dealers doing this is difficult to verify. A lot of people say they know of someone who's doing it. It's possible that these dealers didn't think they would get caught, and if they did, that the FCC wouldn't do anything. Its past enforcement record is poor, according to *MRT* columnist Robert Schwaninger (August 1998 *MRT*) and to Stan Reubenstein, a Denver manufacturers' rep.

Reubenstein said that Denver is a sort of test market anyway, and the FCC had done an audit of all the local SMRs before.

"They came back to us [our company], and said, 'You know, you were the only one that was compliant.' We said, 'That's very nice, what are you going to do to the other people?' They said, 'Nothing,'" Reubenstein said.

The FCC may act this time. At IWCE of this year, the FCC and ITA announced a Memorandum of Understanding to institute technical and administrative protocols whereby interference by non-compliant and unlicensed users would be addressed by frequency advisory committees, such as ITA.

"Remember the MOU?," Mark Crosby, president of ITA, said. "That's what this is."

Crosby said that using private wireless channels for profit violated the rules. "In private pools, at 800MHz and/or 900MHz, there can be shared systems. But everybody on the system needs to be licensed, and the second person needs approval from the first person and so on. It's done on a non-profit basis."

A local operator (we'll call him "Joe") does not think that what dealers are doing is necessarily wrong. He said that Nextel Communications would monopolize the market otherwise, and may do so if these dealers' licenses are revoked. He also said that the FCC had not been helpful in the past.

"There are ways and proper procedures to utilize the spectrum in that capacity. But for my experience on a continued basis, the FCC will not respond or has never set any kind of resolution on that type of spectrum. And in order to get any information on how to comply with that, it's a shot in the dark. It's a gray area. In the last three years, I have just recently gotten the FCC comment on it. I think it's an issue that should be addressed in more of a helpful and a promoting manner instead of a restricting, let's-get-control-and-shut-them-off-type manner," Joe said.

But Crosby and "legitimate" operators have a different perspective. "The rules are codified in Part 90, clearly. We have to manage the spectrum for private wireless. Any of those dealers could have called ITA (or anybody else) and just said, 'How do I do this right by the rules?' The rules are in place to protect the public. I have no sympathy," Crosby said.

He said he didn't see the relevance of Nextel in the issue at hand in Denver.

Frontier Radio in Denver, a Motorola dealer, holds a Metropolitan Trading Area (MTA) license for which it paid $800,000 in the 900MHz auction two years ago. The license allows Frontier to sell subscriber units and airtime to end-users legally. Tom Reuter, the owner, said that Frontier has lost business to the "illegal guys" because they can charge so much less.

Joe the operator plead the case for lower prices for end-users. "The interesting thing about this piece of spectrum is: With the ability for small companies to come in and use it like they're doing right now, that enables a much lower cost to the end-user for wireless radio service. What happens is: When these companies disappear, and the MTA holders control the market, they're going to have to raise rates probably three times on the consumer in order to pay for the license that was received from the FCC," he said.

But the way these dealers may operate is not how the government set it up. Crosby said that the FCC allocated spectrum for certain uses, and that's how it has to be.

"They made an allocation of frequencies for private wireless internal use, and they made an allocation for commercial use. Go bid. Don't fool in the private wireless bands. I will not have it tainted," he said.

For whatever reason, maybe Joe doesn't have much of a chance in an auction where spectrum costs a million dollars.

Reuter compared the spectrum licenses to business licenses. "You have to buy a business license for any business you're in. If you have to buy a business license that costs a million dollars, and some people got one for nothing, it would be tough to compete with them. We didn't have enough money. We went out on a limb. I'm anticipating that we'll be able to compete with all the cellular people and all the other legal people and go out and sell radios and pay my debt off," he said.

What will happen to dealers operating illegally in Denver? Will the FCC really take away their licenses and those of private system operators with whom they have "arrangements?" What happens to that extra spectrum? Will it be saved for further private business use and licensed as businesses apply, or will it go to the commercial auction block?

Joe's suggests that some kind of deal be made. "The people who are utilizing the spectrum in that capacity should have the opportunity to purchase it from them."

But Crosby said, "No deals. If the ITA continues to have a role, I'm not in favor of any deals. The deal is you operate by the rules. If you have customers that need to be licensed, then you need permission from the license-holder. If the initial license-holder is over-licensed and never will have the capacity, those licenses need to come back."

The MOU is good if it resolves complaints. Maybe after this incident, the ITA will be able to resolve other complaints without involving the FCC. Whatever the case, it doesn't look good for the two-way radio dealers who are operating dangerously close to the edge, and the ones who have already gone over.

Nikki Chandler

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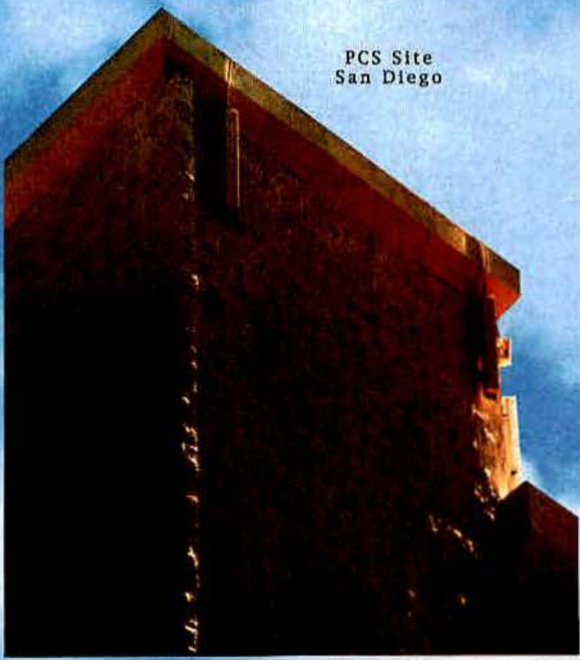

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NEXT MONTH - MRT BUYERS' GUIDE

FEATURES:

Product directory: More than 100 categories of equipment for the mobile radio industry are listed, as well as more than 1,000 suppliers.

Services directory: Mobile radio services such as accounting and billing, consulting, repair, technician training, tower installation and tower space rental.

Company addresses: An alphabetical listing of more than 1,000 suppliers and service providers appears in this section.

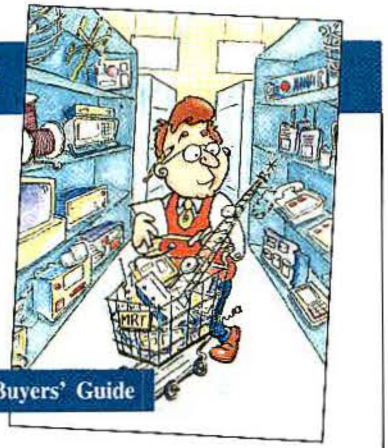
Brand names directory: Sort out which company is associated with specific mobile radio industry brand names in this alphabetized listing.

ALSO:

Index to 1998 features

Don Bishop's editorial

Robert H. Schwaninger's "In the Public Interest."



MRT Buyers' Guide

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calendar

November

4-5—ENTELEC and UTC Joint Seminar on Emerging Wireless Communications, Adams Mark Hotel, Houston. Contact: 202-872-0030; *www.utc.org*.

11-15—Communications Marketing Conference, sponsored by the Communications Marketing Association, San Diego Princess Resort, San Diego. Contact: Bernie Brownson, 303-371-8182.

12-13—AMTEX, sponsored by the American Mobile Telecommunications Association, Fontainebleau Hilton, Miami. Contact: 202-331-7773.

12-13—Third International Congress on Commercial Trunked Radio, sponsored by the International Mobile Telecommunications Association, Fontainebleau Hilton, Miami. Contact: 202-331-7773.

15-18—Telecommunications Resellers Association Fall Conference and Exhibition, sponsored by TRA, Marriott's Orlando World Center, Orlando, FL. Contact: 202-835-9898.

20—Radio Club of America Communications Symposium, 89th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Gerri Hopkins, 908-842-5070.

1999

February

8-10—Wireless, sponsored by the Cellular Telecommunications Industry Association, Ernest Morial Convention Center, New Orleans. Contact: 847-940-2155.

March

8-9—Specialized Wireless Communications Management Conference, sponsored by AMTA, San Diego. Hilton Beach and Tennis Resort, San Diego, Contact: 202-331-7773.

15-16—Wireless Interconnection '99, sponsored by Bellcore, Orlando Marriott - International, Orlando, FL, Contact: 800-521-2673.

28-31—ENTELEC, sponsored by the Energy Telecommunications and Electrical Association, George R. Brown Convention Center, Houston. Contact: 281-357-8700.

April

28-30—International Wireless Communications Expo, co-sponsored by *Mobile Radio Technology*, Las Vegas Convention Center, Las Vegas. Contact: 800-288-8606.

May

10-13—Telecommunications Resellers Association Spring Conference & Exposition, San Diego Marriott, San Diego. Contact: 202-835-9898.

June

1-3—Canadian Wireless, sponsored by the Canadian Wireless Telecommunications Association, Vancouver, Canada. Contact: 613-233-4888, ext. 102.

27-July 1—UTC Telecom '99, sponsored by UTC, Nashville, TN. Contact: 202-857-1881.

28-29—Leadership Conference & Annual Meeting, sponsored by AMTA, ANA Hotel, Washington, DC. Contact: 202-337-7773.

July

14-16—Communications Expo/Show of the Americas, Miami Beach Convention Center, Miami. Contact: Jackie Gonzales, 305-412-9000.

August

8-12—Association of Public-Safety Communications Officials-International (APCO) National Conference, sponsored by APCO, Minneapolis. Contact: 904-322-2500.

17-18—Wireless Interconnection '99, sponsored by Bellcore, San Francisco Marriott - Fisherman's Wharf, San Francisco. Contact: 800-521-2673.

September

23-25—Personal Communication Showcase, sponsored by Personal Communications Industry Association, New Orleans. Contact: 703-739-0300.

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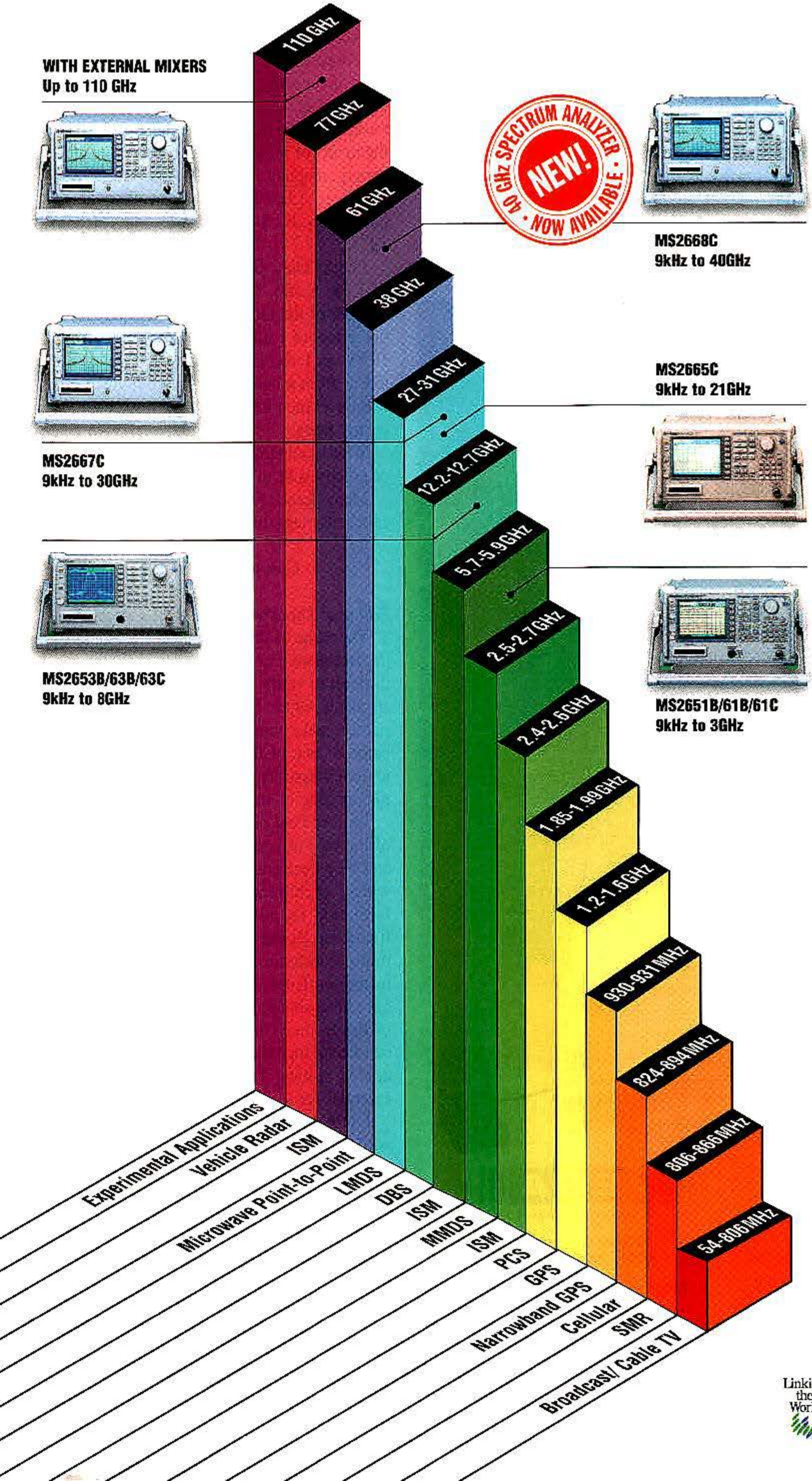
Full Spectrum. Fully Analyzed.



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MRT's new appearance

Thanks for the new improved appearance of the *MRT* publication. It continues to be given the class it rightfully deserves. I enjoy receiving each issue of this captivating electronics publication.

—Jack Forbing
President/system trustee
Northeast Indiana UHF Associates

It's a different world

I really appreciate your magazine and look forward to receiving it each month. I work for a large utility here in California as a telecom tech. This is a different world from two-way radio where I started out. *MRT* helps me stay in touch with the latest in the two-way world.

—Jon Wilhelm
Telecommmunications technician
Pacific Gas & Electric Co.

Link Radio question

What a wonderful article on Fred Link in the August 1998 issue of *MRT*.

In discussing Link Radio (p. 24), you wrote: "Luck ran out with the sale of the business.... His buyers came under federal indictment for reasons I never learned and diverted company resources to pay their legal expenses. Link Radio was in Chapter 11 bankruptcy by 1952 and was liquidated in 1953...."

I never knew this interesting but sad facet of Link Radio. My father, Faust Gonsett, founder of the Gonsett Company, purchased the assets of Link Radio somewhere in the 1950s as I recall—perhaps picking up the pieces from a bankruptcy sale (although this was never mentioned and is only speculation on my part).

What company or who was Link Radio originally sold to?

Many thanks for continuing to publish an excellent magazine.

—Robert F. Gonsett
Communications General Corp.

Editorial Director Don Bishop's response:

The name of the company or the names of the individuals who bought Link Radio are difficult to verify. I heard the late Stu Meyer speak the names, but too fast for me to memorize or make note of them. Fred spoke the name of one of the buyers once, but again, under circumstances that prevented me from memorizing or recording the information.

Neither Fred nor Stu thought of the result of the sale of Link Radio as being positive, and they were not inclined to give me details when I might record and disseminate the information for history. Although my close friendship let me hear many of their stories, it also constrained me from prying unhappy memories from them. A third party might have been able to interview them about some of the business transactions that were less successful than the ones that made for entertaining stories. That information would be essential for a conventional biography.

I telephoned Tom Amoscato, who was with Link Radio in the early years. He said a man named Black, and two others named Murray Platt and Sam Paul were the purchasers of certain assets of Link Radio when it was liquidated. As I talked with Tom, he said, "Hold on, I'll ask my officer manager who also was with Link Radio." When he came back on the line, he had Mr. Platt's first name and the name of Sam Paul, which he did not at first recall. Neither he nor the office manager remembered Mr. Black's first name.

The tower industry: Heading to hype

By Robert H. Schwaninger Jr.

The tower industry is trying to keep pace with the rest of the telecommunications industry. That is to say, the tower industry has gone a little nuts. With skyrocketing prices, overnight experts and overheated financial markets, the tower industry is showing all of the hubris that other market segments have enjoyed and suffered.

About 15 years ago, I was talking with one of my clients when the subject came around to his tower. The structure, a 300-footer with a half-dozen sticks on it, was used to support the client's community repeater business. He also had a few public safety tenants depending on the tower to serve the county.

I asked him what he was charging the public safety guys, and he told me the rent was about 75 bucks a month. This seemed pretty cheap to me, so I asked him where he came up with the rental rate. He couldn't tell me. All I could think of was that he had a good piece of commercial real estate that was netting him about the cost of the gasoline for mowing the grass around the guy wires. That's when I knew that the tower industry was screwy. It still is.

Over the years, I advised my clients to invest more in towers and sites. The rate of return was steady: high and getting higher. Attention was shifting to the unrecognized value of these metal giants, and with the advent of nationwide paging, cellular and PCS systems, the rents were keeping pace with increasing values. Some of my two-way clients are capturing more in "passive" income off of their towers than they ever made selling two-way equipment. The tower boom was on, and the sky was the limit.

NIMBYs and numbskulls

It had to happen. Just when things are going along great, the job gets harder. First there were the NIMBYs, as in "Not In My Back Yard." Towers are big and scary and ugly and look like they produce more electromagnetic energy than Chernobyl. Silly rumors about the health risks of radio operations began to circulate and gain speed with the bogus cellphone cancer scare. Next thing you know, you've got every tree-hugging, owl-kissing, crystal-gazing, earth-mother type talking about the dangers of radio towers. Bull.

We prepared a study in cooperation with a licensed, professional engineer who tests and designs RF equipment for a living. The study compared the level of RF radiation that a person would receive from a 500W paging transmission (operated in direct line [main lobe], without blockage, at 100m) with the RF radiation that same person would receive operating household appliances. Guess what? June Cleaver's being bombarded with more RF energy from the vacuum cleaner than from the paging transmitter. Add the TV, the blender, the PC and the automobile—and the Beaver's cooked. Well, not really.

Illustration by John Hayes

The truth is that NIMBYs don't like towers because they ain't pretty, and some of them blink at night. NIMBYs *do* want their cellphones. They want the efficiency and safety of fire and police communications. They just don't want the tower. Now, *there's* a realistic position.

So, sensing the pulse of America (read, "large carrier lobbying and contributions") the feds passed the Telecom Act of 1996 that in essence says local governments cannot deny zoning based on RF emissions standards, as long as the tower meets the federal exposure standards (which didn't exist when the law was passed). This set off a firestorm of protest from local governments that claimed that the feds had overstepped their bounds and were improperly usurping states' rights.

Lines were drawn and the problem is still being negotiated. Recently, the FCC and some private associations created an arbitration board to resolve disputes. The fact that the board and its participants lack any legal authority to enforce its decision, unless the local government agrees, seems to have been ignored. But it makes for nice-nice window dressing. Sometimes the illusion of progress is the real goal.

'Collocation' and other buzzwords

To create some sugarcoating for the medicine of carrier's machinations forced down the gullet of local governments, the new buzzword "collocation" has come to the fore. Spearheaded by the Site Owners and Manager's Association (SOMA), a wholly owned division of PCIA, tower owners are telling local governments "We've got a plan! We'll try to hold down on the number of towers in your neighborhood by encouraging carriers to *collocate* on the same structure." Anyone familiar with carpooling can understand this concept in a flash.

To kick off its collocation program, PCIA sent out a hip-deep pile of press releases and requests to the U.S. Department of

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington. He is a member of the Radio Club of America.


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Justice (DOJ) seeking "approval" of its program. PCIA sought a DOJ decision on whether encouraging collocation of carriers on sites violated antitrust laws. My conversation with a guy at DOJ who worked on this case suggested that he couldn't understand *why* the question was even asked, but he was doing his job.

The ads tell you that the company is the biggest or the fastest or "feels" your siting needs.

One can easily deduce the reason for the DOJ's reaction to PCIA's request and why approval was a foregone conclusion. Companies "collocate" all the time in office buildings. Why not on towers? The question was silly and the approval was meaningless. So why'd PCIA even ask?

PCIA got about 50 stories out of the trade publications about its seeking approval, fighting for approval, getting approval and acting on its approval. It created something called the "collocation clearinghouse," which presumably is cooler than the old, moribund SOMA Web site. Now, SOMA members and others are being asked to pony up a bunch of dough to list sites on the new collocation Internet site, which is more complicated to master than a Rubik's Cube and far less satisfying.

The whole affair smacks of a gimmick to increase membership in SOMA and make money off the GENUINE, OFFICIALLY APPROVED, ALL-NEW Web site. But then, I guess I'm just overly sensitive about an association that uses the DOJ like a rock star giving testimonials about pantyhose. DOJ didn't say the idea had *merit*, only that it didn't violate any laws.

Consolidation nation

And with success comes consolidation. The big, BIG money guys have awakened to the potential of towers, bringing their investment bankers, CFOs, IPOs, and Armani-suited mentality to the industry. Towers are being bought in bunches at *N* times cash flow adjusted for amortized debt and earnings ratio over cost per pretax payment on a lightning arrester.

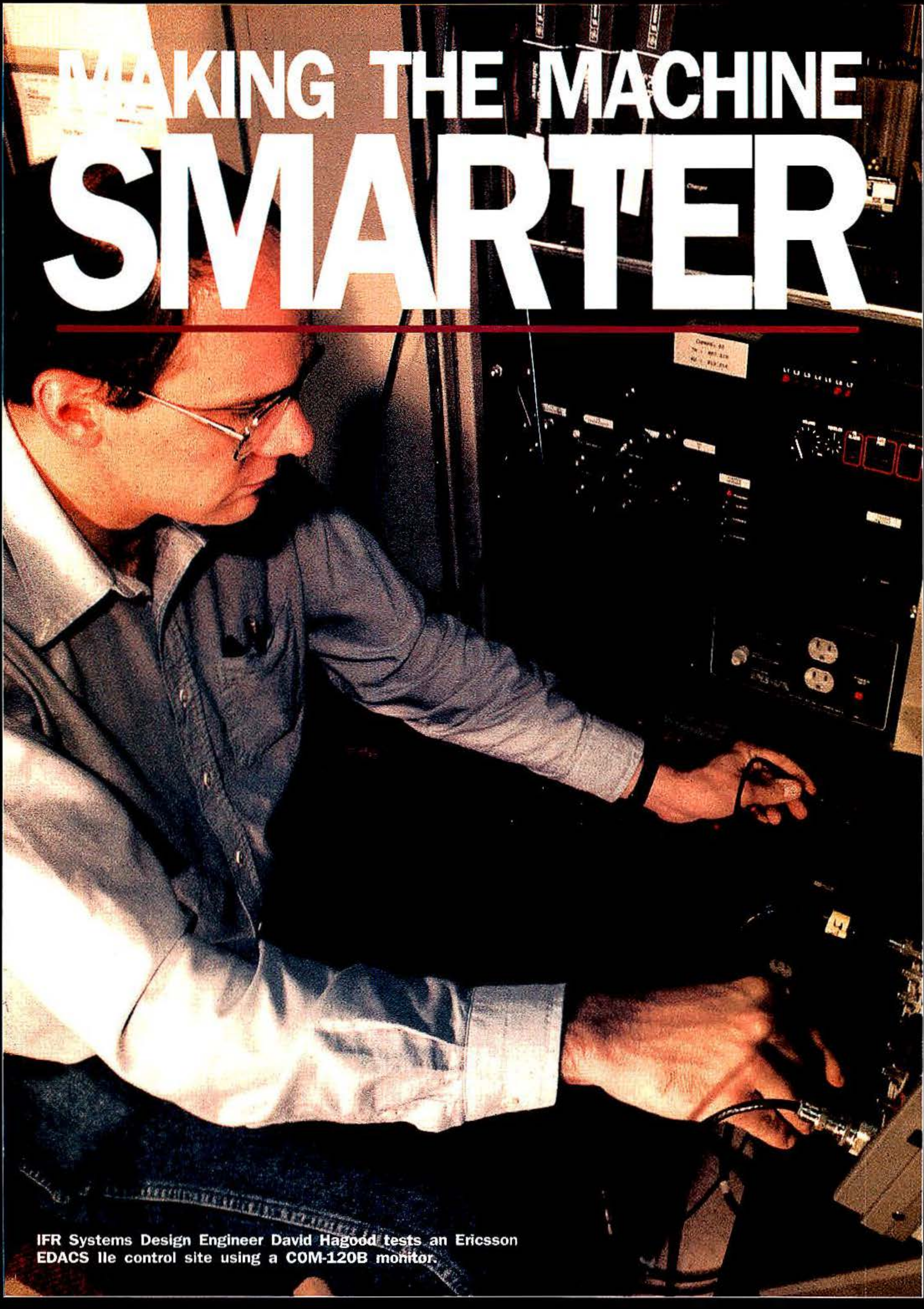
You always know when the institutional investors get into the act. The advertising changes. Instead of leasing space, they're selling *image*. Check out the ads. Instead of the ads telling you where the tower is and how tall it is, the ads tell you that the company is the biggest or fastest or that the company "feels" your siting needs. Nowhere in the copy does it simply tell you about the product: tower space.

I've examined the financials of some of these artsy advertisers. They're buying towers. They're selling stock. They're creating terrific financial vehicles to tantalize Wall Street with expected earnings. What they aren't doing is leasing space and getting the earnings necessary to support their companies. Once again, these financial whiz kids are great at making a company big, but can't be bothered with making the company truly profitable.

A word to these would-be world-beaters in the tower industry: Don't forget that Wall Street severely punishes those companies that year-in and year-out speak only about cash flow and cannot show positive earnings. Learn from the paging industry. Wall Street is *not* a patient investor and two years of negative earnings will guarantee a stock price that is about the same as the cost of a McDonald's Happy Meal.

On the whole, however, the tower industry is quite healthy. Expectations are running a bit high, and demand for space will not reach expectations, leaving some of the players chasing debt service. But the industry is solid—as long as people avoid the hype, the gimmicks and the blue sky, and do the job of building and leasing sites. There simply are no shortcuts. ■

MAKING THE MACHINE SMARTER



IFR Systems Design Engineer David Hagood tests an Ericsson EDACS IIe control site using a COM-120B monitor.

How is communications test equipment designed? How are the needs and suggestions of technicians translated into the capabilities of the next generation of test and measurement sets? To learn the answers to these questions, *MRT* Features Editor David Keckler visited with David Hagood, design engineer with IFR Systems. Based in Wichita, KS, with subsidiaries in Beaverton, WI, and Chandlers Ford, UK, IFR has been developing test equipment for communications, avionics and general measurement since 1968. In recent years, the company has acquired other test equipment manufacturers such as York Technology and Canadian Marconi. IFR's COM-120B service monitor, introduced in 1995, is widely used in the land mobile radio market. Hagood is an electrical engineer, who primarily designs software. For several years he has been the lead software designer for the COM-120 series. He is also an amateur radio enthusiast familiar with the technician's tasks, and he performs the maintenance on his ham group's repeater.

MRT: Does your own ability to function as a technician help with design?

Quite a bit. For example, there was a feature that showed up in version 408. The tracking generator used to be only at the same signal as you were looking at. So one day I was aligning the IF of an amateur repeater, and saying to myself "I'd like to be able to stimulate the thing at the receive center frequency and look at the IF and see my IF response. Wait a minute, there's no *hardware* reason why I can't do that." So I knocked that in as a proven concept, and marketing saw that and said "Make it so!" Because I do use the unit, I can have a feel myself for features that are useful from a technician's point of view.

MRT: You've said that Y2K (*MRT* August) compliance is basically a non-issue for the software in your units.

We did it right the first time. The only other date-related issue is that we're using MS-DOS format internally, so there are the same 25 or so internal counters for the DOS date stamp for the files system, but that's just because of the nature of a DOS file system. The only other information we use is for calibration date. Well, I store the full date as an inside integer, which means I've got until the year 32,767 before it gets to be a sticky issue. I implemented the full leap year calculation, so it knows that 2100 is not a leap year and 2000 is. If you're going to do it, do it right. I'm not programming in the days of COBOL and machines with inadequate memory.

MRT: How much of the software in the last generation of the COM-120B system is new?

I'm personally responsible for probably about 35% of the code that's in the box today. It started out running on a 188 microprocessor; now it's running on a 486. It started out with 0.5MB of memory reserved for program storage; currently, it's running about 11.5MB of program storage, program code. We've added the EDACS protocol, we've added the MPT 1327 trunking protocol and a lot of little features. We added the PCMCIA file system support. A feature that we wanted to put in, then decided against putting in, then decided *against* against putting in, is remote programming language. You can write applications that run entirely within the box. We have a language that we call TMAC, that allows you to write your own applications, so you can write a program and have it resident in the box, and that program can do very sophisticated tests. We can directly access the screen and do things on that screen. We have application programs that you can buy, load into your 120 and run, to automate testing a cell site, or automate testing a radio or do more sophisticated tests than what we saw fit to build in. So it gives us a good way to meet a customer's needs.

MRT: Most options nowadays are already built in and are just triggered by activation codes?

It depends. There are some options for the 120, like an optional function generator, an optional amplifier to give you +13dBm HR that have to be done at a service center because you have to take the unit apart and bolt something into it. But most of the functions in the 120 are software, so it's just a question of enabling those pieces of software.

The nice thing about that is it lets the customer buy a unit—low-ball it—buy just the basic unit. Then, if they say, "Oh, darn, we need a tracking generator on the analyzer." You say "Fine. What's your unit serial number. OK, here are the two magic numbers." And our man—boom—has a tracking generator, and he's not down for three days while the unit goes into the service center.

MRT: So most of the test processing is now in the software that you've built into the unit, as opposed to it being just an information-gathering tool that has to be downloaded into a PC back at the shop?

Right. Exactly. The application programs—those you load into the unit—but we just send you a card that you plug into the unit that pulls the software into the unit and stores it in the unit's internal memory. Like, if you were to buy the Auto-cell NT program, which is a resident macro program for testing cellsites, you plug the card into the front of the unit, the unit pulls the software off the card and stores it in its internal memory, and you now have that option, to run that software.

MRT: How does IFR determine what the ergonomics of operating the unit will be? How do you decide on pressure switches vs. buttons, how the GUI (graphical user interface) for the screen will work? Does one person oversee the integration or is it a team effort with different angles of attack?

It's a little bit of both. During the design phases, the project lead will have an overall vision of the project. But at the same time, people will come in and make suggestions. There's a give-and-take through the initial phases of the design as to how things work out. Then you finalize on the design, and at that point, you either redesign a new box, or live within that design. For the 120, obviously, by the time I became the software lead on the project, the hardware in the box was pretty well defined, and it was just upgrading the software and upgrading the processing hardware within the box.

MRT: How much of the design of a test unit's screen, the GUI, is oriented to the user vs. what's convenient to the programmer or designer?

Well, we try to make it as easy as possible for the technician. My time is paid for once, up front. His time is paid for every time he uses the box. If it's a pain for him to use the box, then he's not as likely to recommend the box, his boss isn't as likely to buy it, and I'm not as likely to get my bonus, so we've tried

to make it as easy as possible. There's an ongoing debate between two kinds of user interface: The 1200-style user interface with lots of knobs and switches and dials and buttons, and the 1600-type and 120-type interface where you have a screen and cursor locations on the screen. They all have their advantages and disadvantages. The nice thing with the 120 is, if you're on a specific cursor location, I can give you all the functions pertinent to that location at once, whereas with knobs and switches and buttons and dials, you sit back and say "Hmm. What knob do I twiddle to make this happen?" But at the same time, when you have your head poked in a repeater chassis, with your arm crooked around sideways holding a scope probe in one place, and *now* you're going to change the generator frequency, and you wonder "Am I in the right cursor field?" And that's where the 1200-style interface works. There are tradeoffs between the two interfaces. The ideal would be to have a little bit of both. That's something I hope to experiment with, with the user interface design, in the future.

MRT: Which needs to get smarter? The machine, or the man?

The machine. You've got a guy who has 12 different types of radios, three different types of repeaters, 14 different types of tests that he needs to conduct. He needs to prepare a printed form for the customer to show what was tested and how it was tested. If he tries to keep all that stuff in his head, he's going to forget where he lives [laughs]. Test instruments are becoming—well, they're a computer, basically. Let the computer store this information. More and more, that's the direction we're trying to go in, we're trying to be able to automate these tests. ... That's why you try to make the base unit, the part that I do the most coding on, pretty flexible, and you give the applications guys all the tools to make all of these little tests a lot more easily. They can knock them out quick and they can knock them out cheap, and if the customer wants, he buys the programming manuals and writes his own applications, and he can automate the tests. So the tech basically pushes the green button and does what it tells him on the screen. The techs will get smarter—they'll have to—but the machine is the one that has to get smarter, quicker.

MRT: How do you know when to stop adding to the box, given weight considerations and other practicalities?

That's usually part of marketing. You try and hit a certain weight target, a certain price target, and then you haggle. "Well, if want three hours' battery life, we're going to have some batteries in this thing, and that's going to add some weight. What are we willing to live without?"

MRT: Are there certain problems with some of the frequencies in use right now, as far the degree of accuracy, that you can safely say you're measuring?

We usually strive for the entire range of the instrument. So like on the COM-120 , we spec from 250kHz to 1GHz, and within that range. It shouldn't matter. The 120 won't tune down to "zero," but we do not spec performance below 250kHz. So, if you're making measurements down there, don't call us 100% accurate—we may be, but we don't claim to be.

MRT: It's uncommon to work down there, though.

Oh, I've done weird things, like take the COM-120's RF input and put it on the audio path of an FM radio and tune in the subcarriers at 67kHz. I was troubleshooting some radios for the blind doing that sort of thing ... I can't think of too many people who are using frequencies that low for anything that we would be measuring, anyway.

MRT: You mentioned radios for the blind. Is there any thought about adding speech recognition or speech synthesis to test equipment?

Obviously, speech synthesis and speech recognition would be nice for a handicapped user; if you're a sight-impaired technician, those would be nice. But if you're trying to make it easier for a technician who's rummaging around inside of the equipment, I think the military has the best idea, a little head-mounted display (HMD) linked back to

the box, so he can look down and see the display in his glasses and look at what he's doing .... On some of our other projects, on the 1900 and the 1800, we have a standard VGA output. Theoretically, if you get an HMD that took standard VGA signals, you could plug that in. ... One of the things I'm looking at is using protocols like X-Windows so that the display of the unit can be shunted over to another computer for display. Just link it over to our test instrument and bring up the display there. One of the things that may show up in future units would be to imbed a Web browser, and have an internal CD-ROM or hard drive that we could get manufacturers to put their service manuals on in HTML and allow the unit to bring that up. If you could couple that with an HMD, you'd have a very good diagnostic system.

MRT: Speaking of military-style equipment, how do military-style hardening and environmental ruggedness fit into test equipment design?

It depends on the customer you're talking to. Obviously, if you're trying to sell to [the military], then being ruggedized to their specs is paramount. For most of our commercial gear, we do some ruggedization by default. On the 900 family spectrum analyzer we made, NASA needed a spectrum analyzer to examine the spectrum around the shuttle while it was in orbit, because they were trying to find good frequencies for ship-to-suit radios. They went to everyone else and said "We need a spectrum analyzer that will go up to 20GHz, that can take shock and vibration, 3Gs of acceleration on launch, and landing stresses *and* work off dc." And everyone else said, "We can *build* you one." And we said, "Yeah, the 900 will do that already. Shock and vibration? That thing will ride down a dirt road in the back of a truck!" They only had to make a couple of modifications for safety issues on the dc connections, wrapped it and away it went.

MRT: Off the shelf?

Yeah.

MRT: Does IFR do any "focus group" sessions with test equipment users or run any type of training classes?

We do have some training classes that we hold here [Wichita]. We don't especially do focus groups *per se*, but we will work with technicians both here at IFR who use the equipment as well as technicians outside. We do try and do an extensive alpha- and beta-test program with technicians in the real world and find out what their issues are. Code goes out with bugs ... When we first release an upgrade, like we did for LTR, or EDACS or MPT 1327 we have it pretty much "ready for prime time" and then let customers use it. But they know they're getting a beta software. We work a deal with them on that, so we don't hit them with a full price and then send service patches out. These guys see and do things that we're *never* going to simulate here, like trying to make a power measurement on a signal with a 3MW AM transmitter sitting next to you.

MRT: What's on the horizon for test equipment needs?

I think the single most important thing in radio communications is moving data, as opposed to moving voice. Ericsson's EDACS has their data protocol on it; more and more you see a lot of police departments using mobile data terminal systems that are plugged into the trunking radio system. Of course, both GSM and CDMA cellular have a data mode that bypasses the vocoder and goes straight down to the bitstream. What you're going to see in all the trunked radio markets is the same thing. As spectrums get tighter, and you can't go with FM anymore, you've got to go with digital just to crunch the spectrum down, and once you're sending bits, "bits is bits." It doesn't matter whether they're representing voice or data. The thing I keep in mind on any new project is six little characters—TCP/IP (transmission control protocol/Internet protocol)—because that's the direction you're going to see a lot of people going in. A lot of people are going with their own data protocols, but they end up reimplementing all the capabilities of TCP/IP. I suspect that in the future, more and more trunked radio systems are going to have IP capability in addition to voice capability. ■

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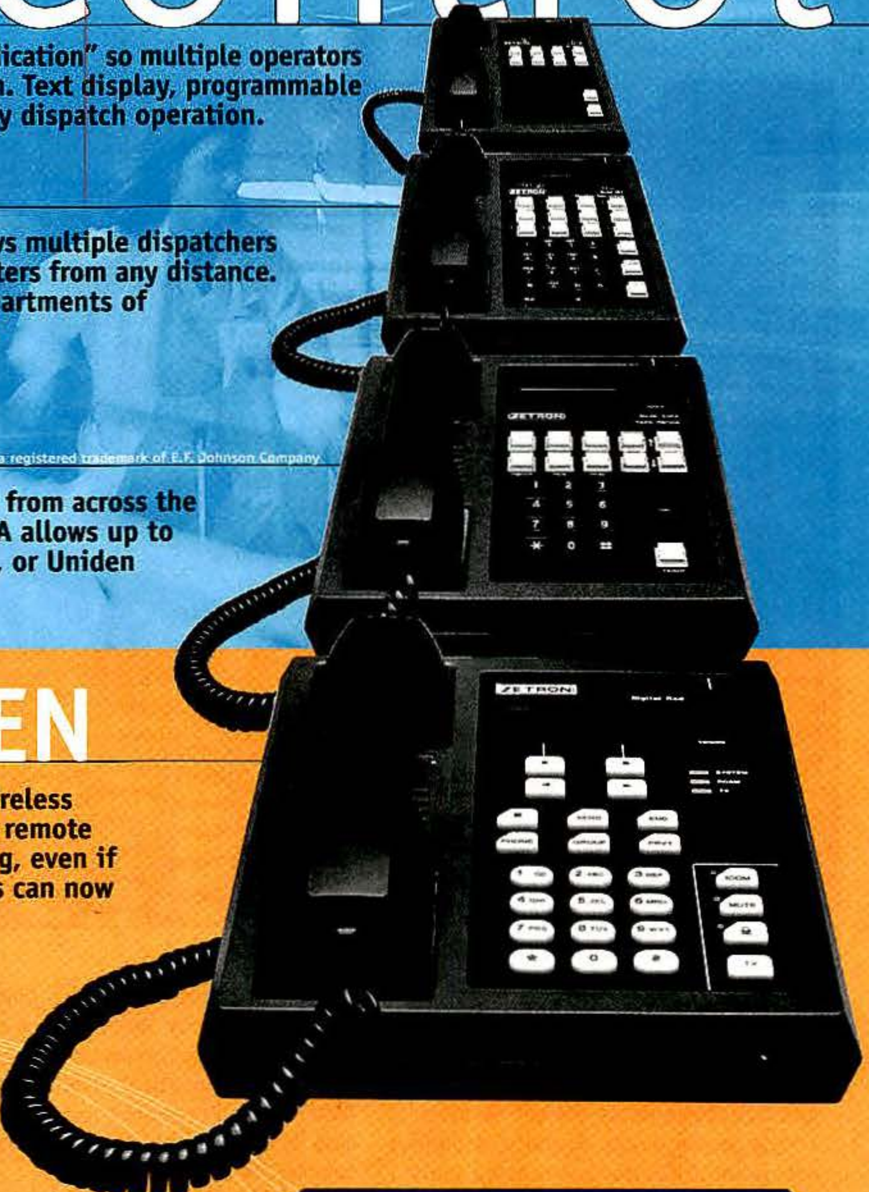

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Connector selection design criteria

Designers must consider a variety of performance issues when selecting connectors for antenna feeder cables.

By Paul Andreescu and Robert Perelman

Transmitting signals to and from tower-mounted antennas is critical to wireless system performance. Usually, designers use foam-dielectric corrugated-copper outer conductor cables to transmit the signal because they have low loss and have proved reliable in outdoor tower-mounted applications. For the past five years, carriers have used the 7/16 DIN European interface to the antenna, which is designed for reliable sealed performance in an outdoor environment. The engineering challenge is to design a transition from the corrugated copper transmission line to the 7/16 DIN interface that does not degrade the RF system performance, has good mechanical and electrical stability, is completely weather-sealed, provides long-term field reliability and is easy for field technicians to install.

A variety of manufacturers offer connector designs to address some of these concerns, but few address all of them. The selection process requires an understanding of the connector options available and how they affect issues such as electrical performance, mechanical performance, weatherproofing, ease and repeatability of installation, and long-term reliability.

Connector Sealing

One critical decision is the method used to form a waterproof seal between the connector, the corrugated outer conductor of the cable and the cable jacket. The intrusion of any amount of water vapor over a long period of time can corrode contact surfaces. The result is an increase in passive-intermodulation (PIM) distortion, which degrades system signal-to-noise

Andreescu is connector design manager, Eupen, Belgium, and Perelman is vice president of sales and marketing for Eupen Cable USA, Orange, CT. Andreescu's email address is *p.andreescu@aleph-1.euronet.be*. Perelman's email address is *rperelman@eupen.com*.

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ratio and eventually leads to dropped or non-completed calls, revenue loss and customer dissatisfaction.

The most common method of achieving this seal, the use of one or more O-rings, is not necessarily the best option. O-rings are designed for making a reliable seal between two machined, nearly perfect metal surfaces. They are used with a high degree of reliability to provide a weather seal in the interface between the male and female 7/16 DIN connectors. This is a different application from using an O-ring to form a seal between the connector and the corrugated copper outer conductor, or between the connector and the jacket of the cable.

Unfortunately, the corrugated copper outer conductor is an imperfect surface. Because of the manufacturing method, it is not perfectly round, often has longitudinal scratches from the drawing dies used in the manufacturing process and has a weld seam, which is not perfectly flush with the surface. As a result, an O-ring does not provide a reliable seal to the corrugated copper outer conductor.

The seal to the polyethylene jacket can create other problems. The jacket's surface is even more imperfect than the copper outer conductor because the manufacturing tolerances are greater, and it is a softer material subject to more damage. If this seal fails, it creates two problems. First, water that seeps under the jacket of the cable at the connector interface can migrate along the cable under the jacket and corrode the ground straps. This leads to poor grounding and increases vulnerability to damage from lightning strikes.

A hole in the jacket along the cable also can lead to problems. The water can migrate along the cable to the connector. If there is not a good seal between the connector and the jacket, moisture can get into the connector interface and cause corrosion. Although these problems are more serious in cables with helical or screw-thread corrugations, even annular or ring corrugated cables are not sealed between the jacket and the outer conductor, which allows water to migrate along the length of the cable in this interface.

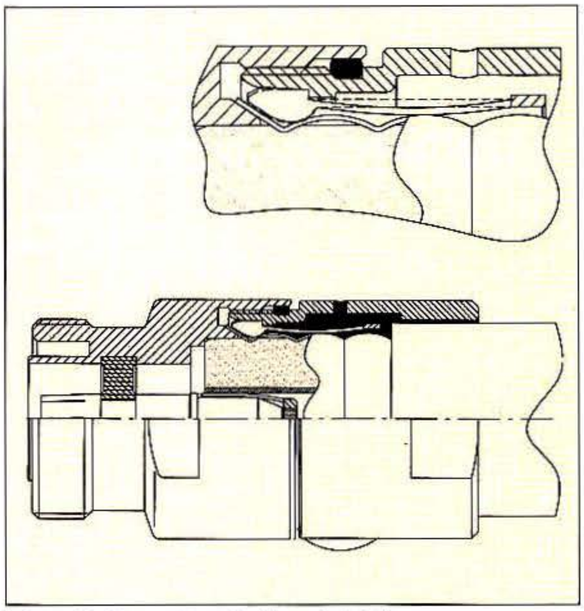

Figure 1. Connector attachment details.

A properly selected polymeric sealant, such as room-temperature vulcanizing (RTV) silicone, is one reliable method to produce a long-term seal to the corrugated copper. This material is injected into the back end of the properly designed connector to completely encapsulate the end of the jacket, the corrugated copper and the connector body. It hardens within a few hours of application and fills in all of the irregular areas on the outer

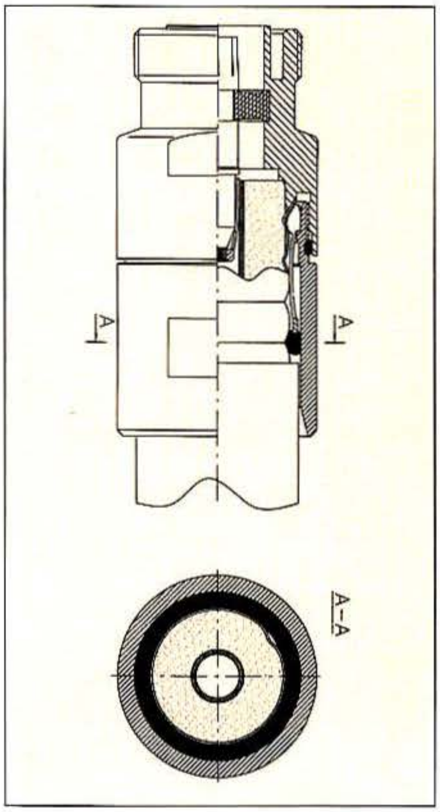

Figure 2. O-ring seals leak.

conductor. Appropriate RTV sealants provide a high degree of adhesion to all of the materials, including the copper of the cable outer conductor, the connector body and the cable jacket.

These sealants actually absorb water as they harden, removing any residual water vapor that may have been in the connector interface. Essentially, they act as a desiccant to protect the contact parts from corrosion.

Properly installed connectors sealed with this method resist moisture intrusion for many years.

On the other hand, field reports show that connectors with O-ring seals are a constant source of maintenance and reliability problems. Even the use of additional wraps of butyl rubber and electrical tape cannot keep the moisture out of the connector interface over a long period of time. But some appropriate uses for O-rings exist. For example, O-ring sealed connectors are ideal for temporary installations because they are easy to reuse, and they provide adequate protection from moisture intrusion for a few months. With the RTV silicone method, the connector can be cleaned and reused once the silicone hardens, but it is time-consuming.

Outer conductor prep and clamping

There is a choice of trim dimensions for the different cable components and methods to achieve the dimensions. The concept of cutting the cable flush for connector attachment is simple, but it leads to one major performance problem—the copper chips from the saw cut get embedded into the foam dielectric of the cable and are almost impossible to remove. In fact, any method of cutting the outer conductor that requires a cut toward the foam dielectric can introduce copper particles into the dielectric. Generally, these particles will not cause a problem until they are adjacent to the center or outer conductors. The poor contact that exists between the conductor and the copper particles will create a source of PIM.

The can-opener method, which eliminates the risk of contaminating the dielectric with copper particles, is one way to trim the outer conductor. In this method, the outer conductor is pulled away from the dielectric with pliers and stripped even with the back portion of the connector. The result is a flared conductor, with no copper-chip contamination.

The method used to achieve high-contact pressures also is critical to connector performance. High-contact pressures are essential to the PIM performance of the connector and to minimize RF loss through the connector interface. In many connector designs, tightening the two halves of the connector directly

applies force to the outer conductor. But with this approach, the temperature cycling is in the normal installation environment, and "metal creep," which decreases contact pressure over time, degrades connector performance and loosens the cable attachment. Spring contacts for both center and outer conductors can be used to eliminate the potential of reducing the outer conductor contact pressure.

How many pieces?

From a production perspective, it is economical to produce the connector in many parts and assemble them. But it is easy to lose the small parts in the field, especially when installing them on a tower. A chance of incorrect assembly also exists. In either case, the connector will not perform to its design specifications or may not be installable at all.

Another option is to assemble most of the parts in the factory. This assures that the pin depth is set correctly in the finished product, which is essential for proper return loss performance. It greatly reduces the potential for lost parts and increases the likelihood that the connector will be installed correctly.

System reliability

Even though a reliable cable type and a reliable interface are used for antenna feeder applications, this is one of the most troubled portions of a wireless communications system. Usually, designers do not pay enough attention to the design of the cable connector that serves as a transition from the corrugated copper cable to the 7/16 DIN interface. Although it looks like a simple device, it must perform several functions simultaneously in a variety of harsh environments. And it must do so with a high degree of reliability for the system to perform as required. In addition, the connectors must be designed to be installed by semi-skilled technicians in a field environment. Achieving all of these objectives is a major design challenge that requires careful attention to many details.

In addition to providing a reliable electrical and mechanical interface to the cable, the connector also must provide a reliable weatherproof seal to the cable. Allowing the intrusion of water into the interface will corrode the contact parts, which will degrade electrical performance. In particular, contact surface corrosion will produce PIM, which can degrade system performance and result in dropped calls. In addition, moisture in the cable can increase the attenuation of the signal. This can reduce the radiated signal and reduce the coverage area leading directly to customer dissatisfaction and revenue loss. This problem is difficult to troubleshoot and to identify because it typically occurs as a gradual degradation rather than as a catastrophic change in system performance.

Electrically, the connector serves as a short section of transmission line and provides a transition from the transmission line size of the cable to the transmission line size of the 7/16 DIN or type N interface. Therefore, its performance can be measured in terms of the typical transmission line parameters: insertion loss and return loss. In addition, because points of contact exist on both the center and outer conductors, the maintenance of high-contact pressure is essential to the long-term performance of the connector. Over time, poor contacts will result in high levels of PIM and an increase in insertion loss. Applying a spring-loaded contact for use of high-contact pressure is essential to maintaining the contact pressure and preventing the connector from coming loose, which can increase PIM.

Choosing a well-designed connector will contribute greatly to system reliability. Incorrectly designed connectors will require constant maintenance and will reduce customer satisfaction and revenues. Too often designers do not give sufficient attention to this area of system design. As a result, system reliability is unnecessarily compromised. ■

Simulcast design for the Flex paging protocol

An efficient system design can meet the simulcast performance constraints as systems transition to higher Flex speeds. Power and delay management techniques can bring the performance of the coverage area within the specified sensitivity and SDS limits.

By Slim Souissi, Ph.D., Stephen Sek and Casey Hill

The Flex paging protocol, introduced in 1993, is becoming the worldwide standard for paging. More than 40 million Flex-based pagers are in service around the world. The largest U.S. service providers have adopted the protocol, as have service providers in Canada, Latin America, Asia, Africa, Europe and the Middle East.

During the last year, several service providers have begun upgrading their Flex networks to higher speeds to meet demands for increased capacity. Network upgrades have been successfully tested in the real-world RF environment where intermodulation, fading, adjacent channel interference and, most importantly, simulcast distortions can degrade service quality. As a result, carriers realize that upgrading a network from 1,600bps to 6,400bps is complex, yet possible[5].

The simulcast environment

Simulcasting means broadcasting the same message from multiple transmitters operating on the same frequency. Flex uses simulcasting to reliably deliver messages to pagers located anywhere within the coverage area.

Simulcasting boosts the coverage over a wide service area while maintaining a high level of building penetration. Macrodiversity gives simulcast its inherent strengths. Regardless of the pager's location inside the building, there is always a chance that one of the signals around the building will reach the pager. Moreover, signals from different transmitters can combine constructively, boosting the overall signal level.

Unfortunately, simulcast benefits are inevitably coupled with signal distortion[1], which becomes more problematic for the system designer as the channel data rate increases. The quality of signals generated by different transmitters, when received at the pagers, depends on the signals' magnitude, relative delays and relative frequencies. Viewed from the pager's physical location, the path lengths to the various transmitting sources generally are not the same. The combination of several paths contributes to distortions known as *simulcast delay spread* (SDS). SDS is regarded as the most challenging effect that the system designer has to design for. Another important source of simulcast distortion is *zero beating*, a phase cancellation condition. When signals are received from transmitters at offset frequencies, severe periodic signal cancellations may occur, especially in high-rise building and open-overlap areas.

Simulcast delay spread

Simulcast delay spread results from intersymbol interference that occurs when several replicas of the same signal reach the receiver with unequal delays. SDS distortions can be observed in overlap areas where the relative delay between multiple received paths is in excess of the system SDS tolerance[2,3]. The rule of thumb for admissible SDS performance is to design the system

Souissi is principal staff engineer, Sek is senior staff engineer and Hill is director of system technology research for the Motorola Messaging Systems Product Group, Fort Worth, TX. Flex is a Motorola trademark.

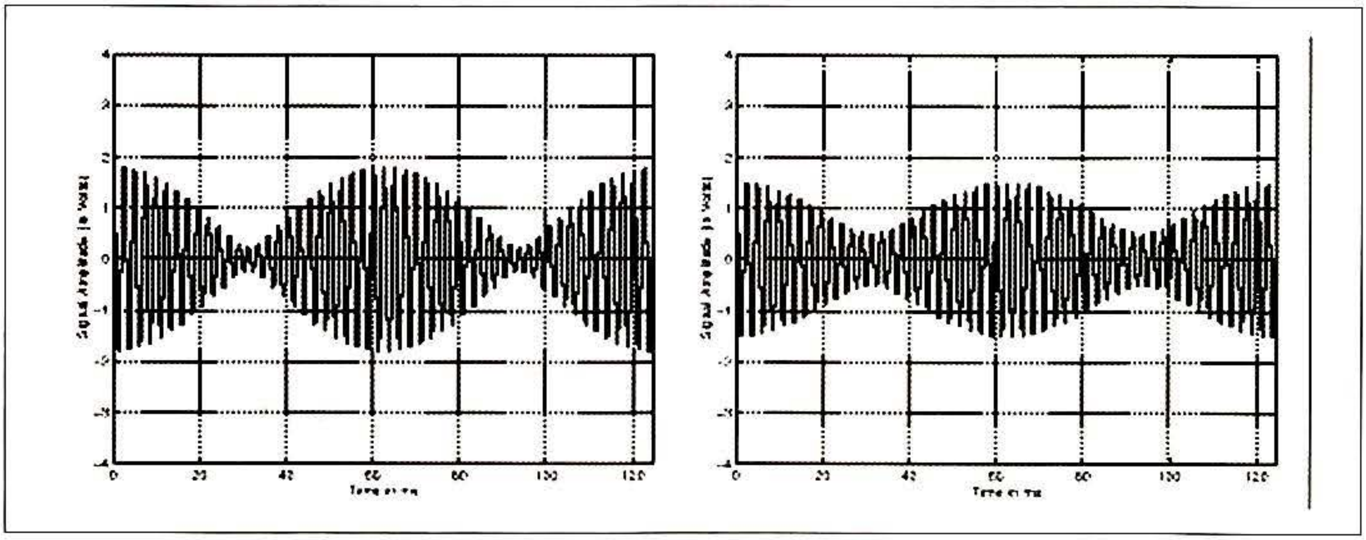

Figure 1. Zero beating process in the time domain: (a) ΔP=1dB, (b) ΔP=3dB.

POWER DIFFERENTIAL (dB)	CANCELLATION DEPTH (dB)
0	INFINITE
1	24.8
2	18.8
3	15.3
4	12.9
5	11.1
10	5.7

Table 1. Cancellation depth as a function of differential power for a two-path simulcast model. (Cancellation depth is measured from the maximum combined received power.)

OFFSET (Hz)	CANCELLATION DURATION (μs)	CANCELLATION DURATION IN SYMBOLS (@6,400bps)
1	204,800	656
15	13,700	44
30	6,800	22
45	4,600	15
60	3,400	11

Table 2. Cancellation duration at 10dB below maximum combined signal strength for a two-path simulcast model.

for a ¼-symbol SDS tolerance. A conservative design goal should consider approximately 15% to 20% of the symbol period. This is about 50μs for Flex systems operating at 6,400bps. (For a two-path static simulcast model with 1dB power differential, 16Hz offset and at 30dB above pager sensitivity, the pager should have acceptable performance when the differential delay between the two paths is around a 1/4 of a symbol.)

Zero beating

Zero beating is a phase cancellation condition that occurs when two or more transmitters send the same data at slightly offset frequencies. Two transmitters simulcasting the same carrier with a small frequency offset illustrates the zero beating process. Figure 1 on page 28 shows the cancellation effect in the time domain. Frequency offset and power differential are the key parameters that control this process. Cancellations occur periodically at the frequency offset f_o. The smaller the power differential between the two paths becomes, the deeper the cancellations become, as shown in Table 1 above.

For example, a power differential of 1dB causes cancellation depths of about 25dB. As the frequency difference between the two paths becomes smaller, cancellations occur less frequently but with longer duration. Inversely, at high offset frequencies, shorter cancellations occur more frequently. (See Table 2 above.) Frequency offset is the only parameter that controls cancellation duration. It is interesting that for a significant observation interval, the total cumulative period of time during which the signal power goes below a certain threshold is independent of the offset frequency.

This phase cancellation effect is mitigated in Flex protocol systems through error correction and data interleaving.

Simulcast performance

The following section provides information about two key pager performance measures; namely, delay capture performance and delay spread performance.

Pager delay capture performance

An indication of a pager's ability to withstand simulcast distortions is its delay capture performance. Delay capture curves reflect the pager's ability to defeat zero beating and SDS distortions. Figure 2 on page 30 shows an example of static delay capture curves for a Flex 6,400bps system. Two

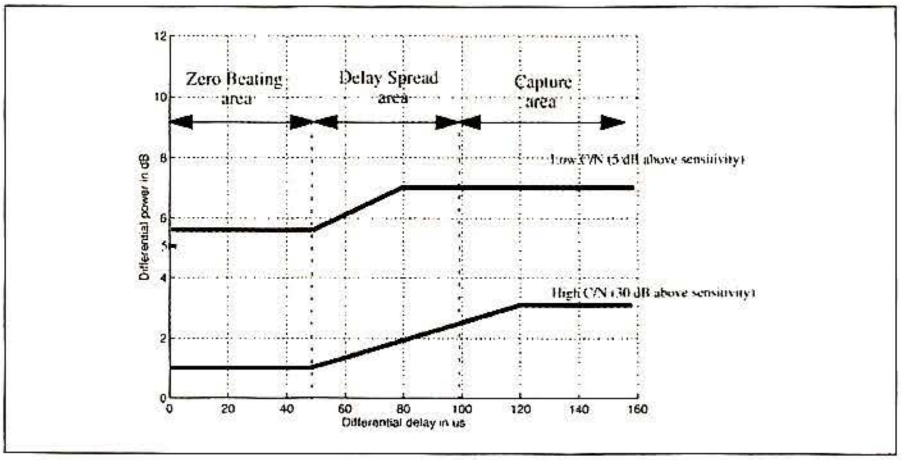

Figure 2. An example of Flex 6,400bps static two-path delay capture curves at 0.1% decoded WER with 16Hz frequency offset.

curves illustrate the pager's performance under different channel conditions (high carrier-to-noise ratio [C/N] versus low C/N). Each curve represents the set of operating points for which the decoded word error rate (WER) equals 0.1%. Capture curves show three operating regions:

- ❑ low delay operating region or zero beating area.
- ❑ transition region or delay-limited area.
- ❑ high delay operating region or capture area.

Low delay operating region—When the pager operates at low C/N, its tolerance to zero beating is diminished. In fact, the available amount of signal power is not great enough to compensate for the periodic cancellations. The pager performance depends primarily on the power differential between the two simulcast paths. Only cancellations with moderate depth are tolerable.

When the signal strength is high, the pager tolerance to zero beating distortion improves. Severe cancellations caused by low differential powers can be filled in partially or completely by the strong received signal. Figure 2 shows that for high C/N values (about 30dB above pager sensitivity) and for a differential delay of 50μs, the pager can tolerate cancellations produced by a power differential as low as 1dB.

Transition region—At delay values of approximately ¼-symbol in duration, the combined effect of delay spread and zero beating causes additional signal distortions. As the differential delay increases, the pager tolerance to zero beating is significantly reduced. This increase means that only moderate power differentials are tolerated.

High delay operating region—Delay spread is the main cause of signal distortion. For delays greater than ½-symbol in duration, the pager performance becomes unacceptable, even at locations with high signal strength.

Only capture can guarantee acceptable pager performance. The pager capture ratio is the power differential, value between the strong and weak signal, at which the pager performs at a given quality level. The ratio is an indication of the receiver's capability to detect a strong signal in the presence of a weak interfering signal. The capture ratio depends on the received signal strength. Figure 2 shows that at high C/N, the capture ratio is only 3dB, but it exceeds 7dB at low C/N.

Pager delay spread performance

Another approach for evaluating pager performance in a simulcast environment uses the delay spread model. The root-mean square (RMS) value of the simulcast path delays, weighted by their respective power levels, represents a reliable parameter for evaluating pager SDS performance[1].

This parameter is called *simulcast delay spread* and noted as T_m:

$$T_m = 2\sqrt{\frac{\sum_{i=1}^{N} P_i d_i^2}{\sum_{i=1}^{N} P_i} - \frac{\left(\sum_{i=1}^{N} P_i d_i\right)^2}{\left(\sum_{i=1}^{N} P_i\right)^2}}.$$

P_i and d_i, respectively, represent the power and delay of the i^{th} signal. The above equation shows that the same T_m value can be produced by a multitude of power and delay combinations. For a fixed T_m value and a fixed C/N level, in a fading environment, the pager performance remains fairly unchanged.

This interesting property makes SDS evaluation an attractive procedure for rating pager performance. Typical delay-spread curves have a "hockey stick" shape as illustrated by Figure 3 at the right. In a low SDS environment, the required C/N that guarantees a certain level of pager performance (for example, 0.1% WER) slightly exceeds pager sensitivity.

Under such conditions, pager performance is only limited by the received signal strength. In the vicinity of the SDS limit, the pager performance degrades severely. Signal cancellations become so severe that even in a high signal strength environment, system performance becomes unacceptable.

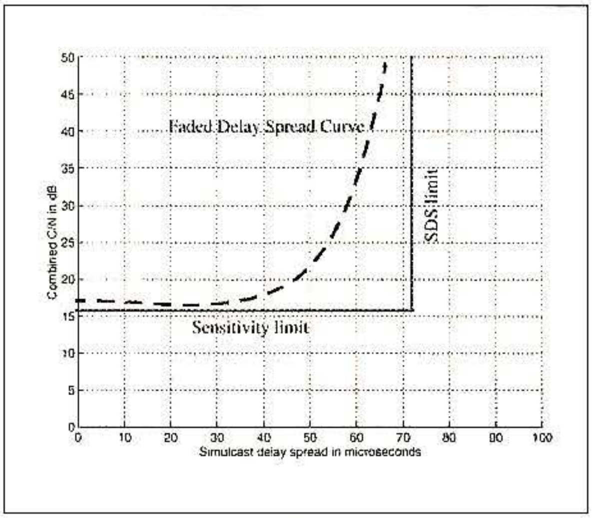

Figure 3. An example of a faded delay spread curve at 0.1% decoded WER for Flex 6,400bps.

Design system for simulcast

Pager simulcast performance is a factor in the overall system coverage performance. For example, it is simple to design a simulcast system for large SDS tolerance because performance is mostly limited by the pager sensitivity. The design becomes challenging if SDS tolerance is low. The mission of the system designer is first, to understand the pager simulcast requirements, and second, to ensure that every coverage area meets these requirements.

Design system for simulcast delay spread

Traditional low data-rate simulcast systems such as POCSAG or Flex 1,600bps, do not need to address the SDS problem. This is primarily due to the large symbol duration that provides an inherent immunity to delay spread. High-speed simulcast systems are

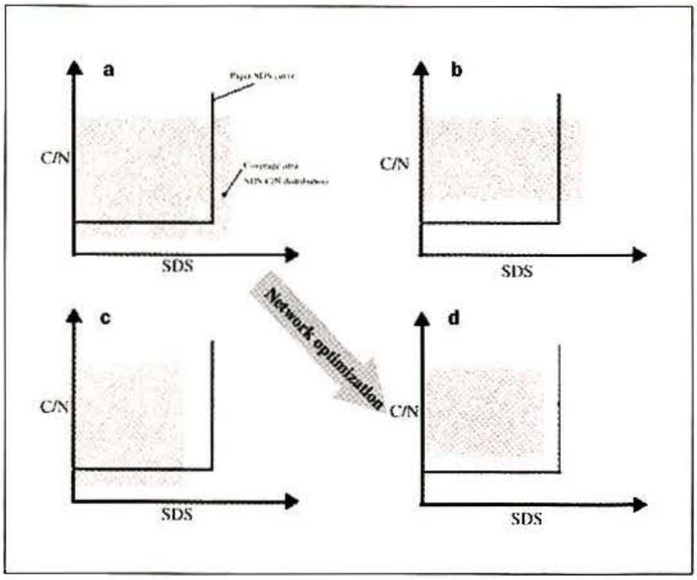

Figure 4. Simulcast system optimization. (a) Inadequate coverage and SDS problems. The system needs more transmitters (or higher power transmitters/higher sites) and SDS optimization. (b) Adequate signal strength but SDS problems: The system needs SDS optimization. (c) Inadequate coverage and good SDS performance: The system needs more transmitters (or higher power transmitters/higher sites) and possibly SDS optimization. (d) System optimization for signal strength coverage and SDS performance.

more vulnerable to SDS problems. Paging carriers are therefore compelled to design and optimize their systems methodically to guarantee acceptable coverage performance.

Figure 4 at the left graphs the process of optimizing a simulcast system. Two axes are used to approximate the pager performance. The verticle axis reflects the pager sensitivity threshold, while the horizontal axis sets the pager SDS limit. To guarantee acceptable performance for a given location within the coverage area, two conditions must be fulfilled:

❑ The signal strength must be above the sensitivity threshold.

❑ The delay spread distortion must be within the SDS capabilities.

The goal of the system designer is to ensure that 95% of the coverage area falls within the SDS limits (assuming that the paging system is designed for 95% area reliability). For example, Figure 4a represents a system design that lacks signal power and has several areas with SDS problems. On the other hand, figure 4d represents a system that is optimized for simulcast.

The authors[2,4] have discussed power delay management techniques that can bring the entire coverage area within the pager-imposed limits and can optimize coverage performance.

A simple optimization example using the Motorola propagation tool (MOZAIK) illustrates the coverage performance of each of the scenarios described in Figure 5 on page 33. Each coverage map shown in Figure 5 corresponds to the scenario in Figure 4 with the same label. Figure 5a represents a system where two sites are intentionally placed much higher than the three other sites to cause delay spread problems. The graph shows that the system has SDS and sensitivity problems.

The system illustrated by Figure 5b uses high sites with high transmission power. The simulation shows a severe SDS problem across the entire coverage area. Figure 5c shows a typical example of a sensitivity-limited system. Increased signal strength throughout the coverage area is needed. Signal strength can be increased by adding

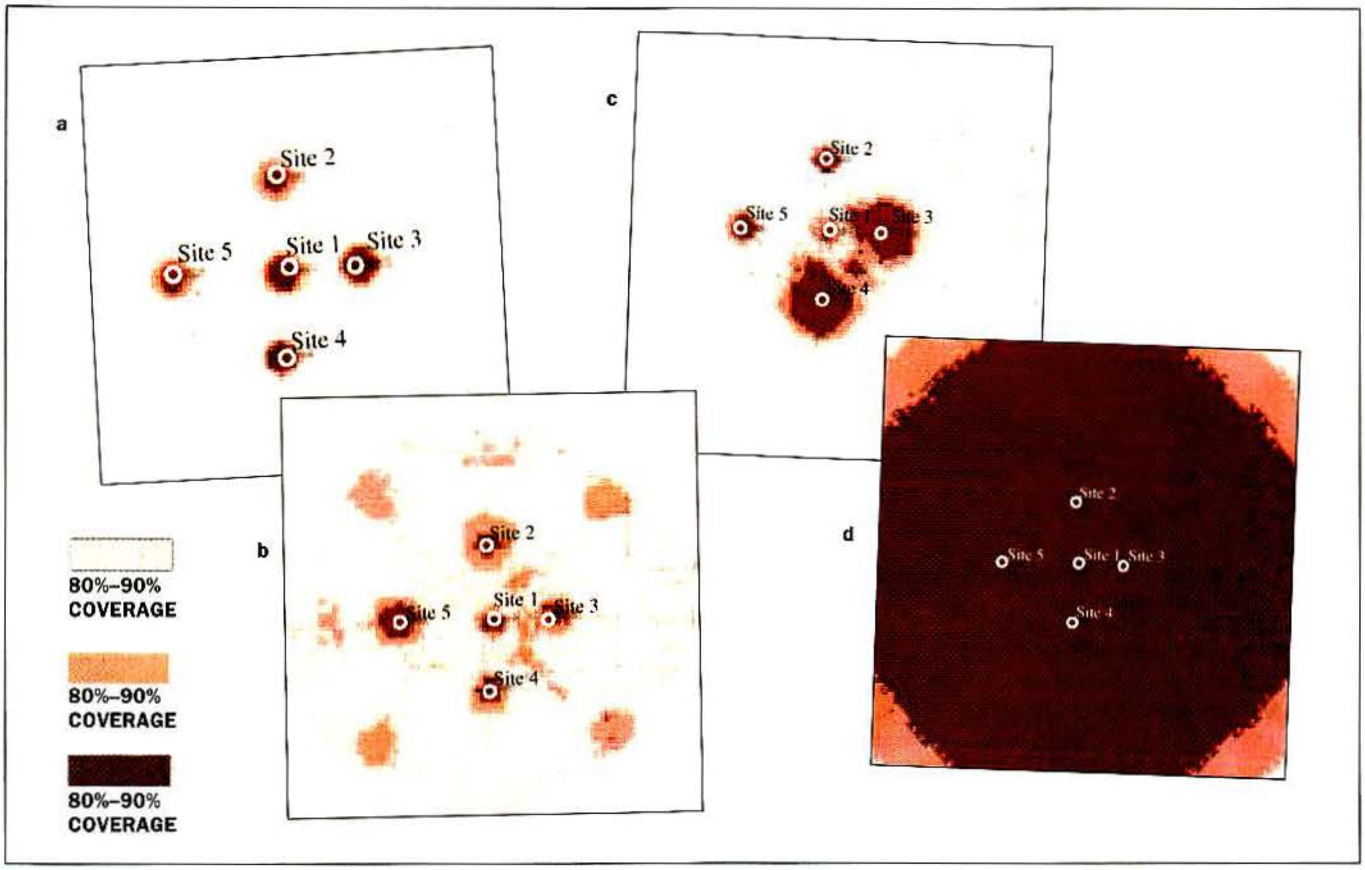

Figure 5. Simulcast system optimization. (a) Sensitivity and SDS problems; omni antennas on all sites, sites 3 and 4 are highest. (b) SDS problems; all sites are high with high transmit power. (c) Sensitivity problems; omni antenna on all sites, low-height, low-power sites. (d) System optimized for signal strength coverage and SDS performance; site 1, omni antenna, sites 2–5 with directional antennas and launch delays.

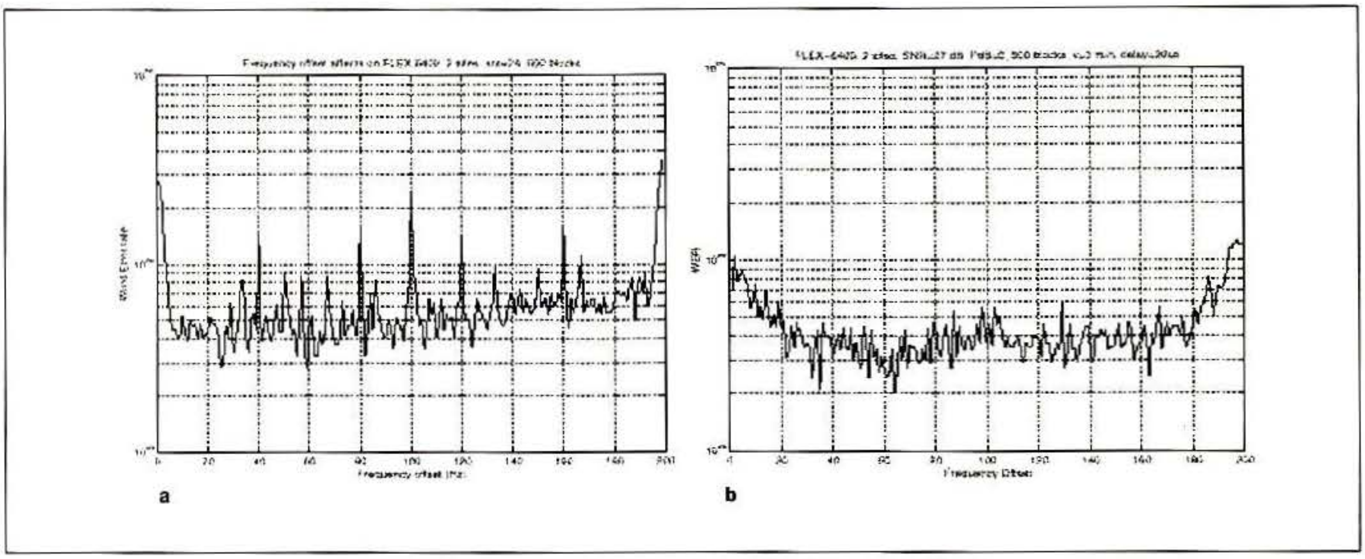

Figure 6. Simulated WER versus frequency offset for Flex 6,400bps: (a) static; (b) faded at 3mph.

sites, increasing the transmit power or increasing the antennas' heights. Figure 5d shows an optimized system. The sites' heights and transmission power are increased to meet the sensitivity requirements, while directional antennas and launch delays are used on the external sites to meet the SDS requirements.

Design system for zero beating: frequency offsets

An offset plan manages the zero beating process. The goal is to enhance performance in high rise and overlap areas where the power differential between signals is low (in the order of 2dB–3dB or less). Optimum offset frequencies regulate the cancellation duration and the frequency of cancellation to match the coding and interleaving capabilities of the Flex protocol.

Computer simulations, laboratory tests and field measurements show that frequency offsets contribute to a substantial improvement in the coverage performance of zero beating areas. This is true in both static and fading environments. Figure 6 above shows the simulated results of WER vs. frequency offset for Flex 6400 in static (Figure 6a) and 3mph slow fade (Figure 6b) environments.

Figure 7 on page 35 shows the field-measured results of WER vs. frequency offset for Flex 6400 in a static environment. Note that offsets like 1Hz, 40Hz, 50Hz and 100Hz all produce relatively high WER.

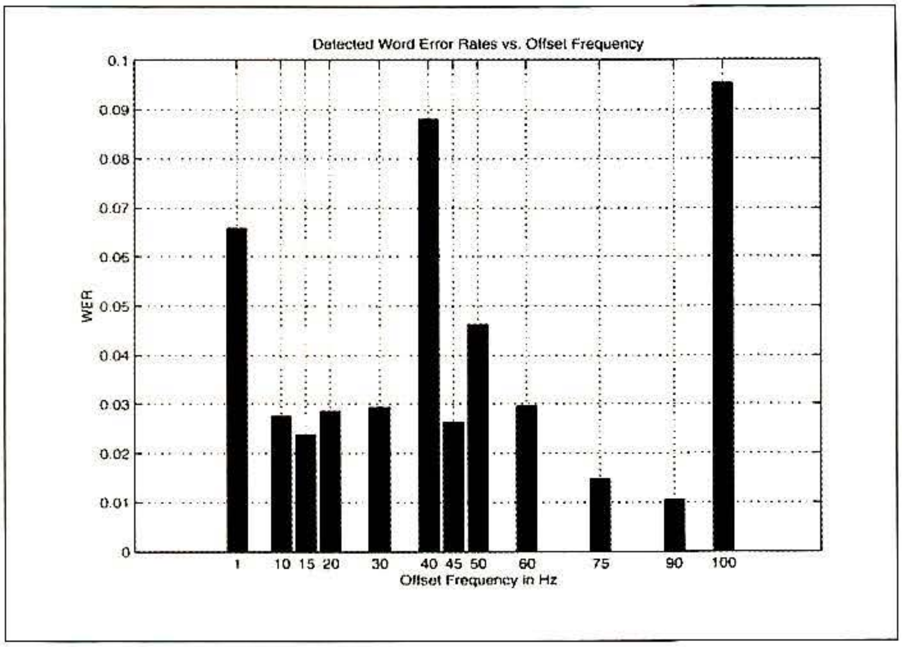

Figure 7. Static field measured WER versus frequency offset for Flex 6,400bps.

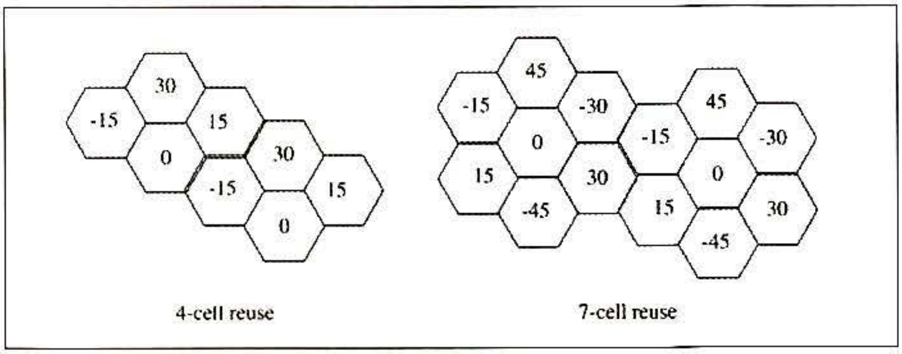

Figure 8. Examples of frequency offset plans for Flex 6,400bps.

The results show that good offset frequencies are found in the range (10Hz to 90Hz) (Figure 6a). The recommended offset frequencies are {−45Hz, −30Hz, −15Hz, 0Hz, 15Hz, 30Hz, 45Hz}. Offsets that are too high should be avoided because they result in excessive pager sensitivity loss.

Examples of four-cell and seven-cell offset frequency reuse patterns are proposed in Figure 8 above. With careful offset assignment to each cell, four offset frequencies are sufficient to cover any type of coverage area without adjacent cells sharing the same offset. However, five to seven offset frequencies provide more flexibility, especially for future system expansion.

Conclusion

This article provides guidelines for simulcast system design that meet the constraints imposed by upgrading a paging system to higher speeds. Power and delay management techniques can bring the performance of the entire coverage area within the sensitivity and SDS design constraints. Frequency offset reuse plans for Flex 6,400bps are recommended. The plans alleviate zero beating problems in high rise building and overlap areas and improve the coverage performance of the overall system. ■

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Acknowledgment

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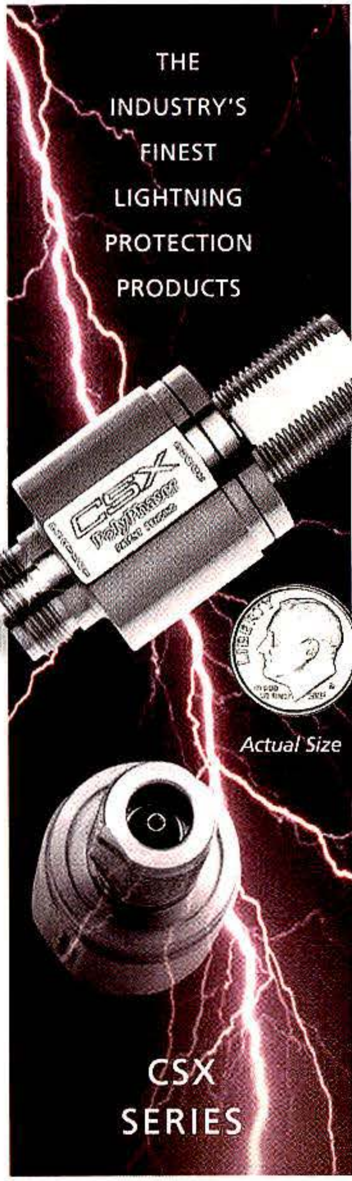

Remote testing of EDACS trunking systems

An enhanced simulcast configuration provides for testing of each channel in a trunking system.

By Jeff Ashley

Radio manufacturers have been building trunking systems for years, each system with its own unique methods and architectures. In an enhanced simulcast configuration, Ericsson's Enhanced Digital Access Communications System (EDACS) incorporates a remote-controlled, automated system capable of testing each channel in the trunking system. Channel equipment indicating a fault condition can be automatically disabled and alarm indications at a central location alert employees to technical problems.

Automated system testing

The GETC (GE Trunking Card) is a unit developed by Ericsson to perform a variety of functions within a trunking environment, depending on its internal programming and strapping options. When used as a component of the automated test system, this unit can take the form of a TUAI (Test Unit Alarm Interface) GETC. The TUAI GETC, working in conjunction with a specially programmed trunked mobile radio called a test unit (TU), a separate radio dedicated to monitoring the outbound control channel data called a control channel monitor (CCM) and an alarm shelf create the subsystem that accomplishes the remote-end testing of each channel's trunking functions at programmable intervals of one minute or longer.

Digital/analog testing

When idle, the TU monitors the outbound control channel data, as any mobile unit in the system would. If, while monitoring, the TU notices problems regarding control channel sync, incorrect messaging or wrong Site ID, it will send the corresponding fault information to the TUAI GETC over a 19.2kbps serial data link.

The testing process begins when the site controller issues a special test call request on the outbound control channel.

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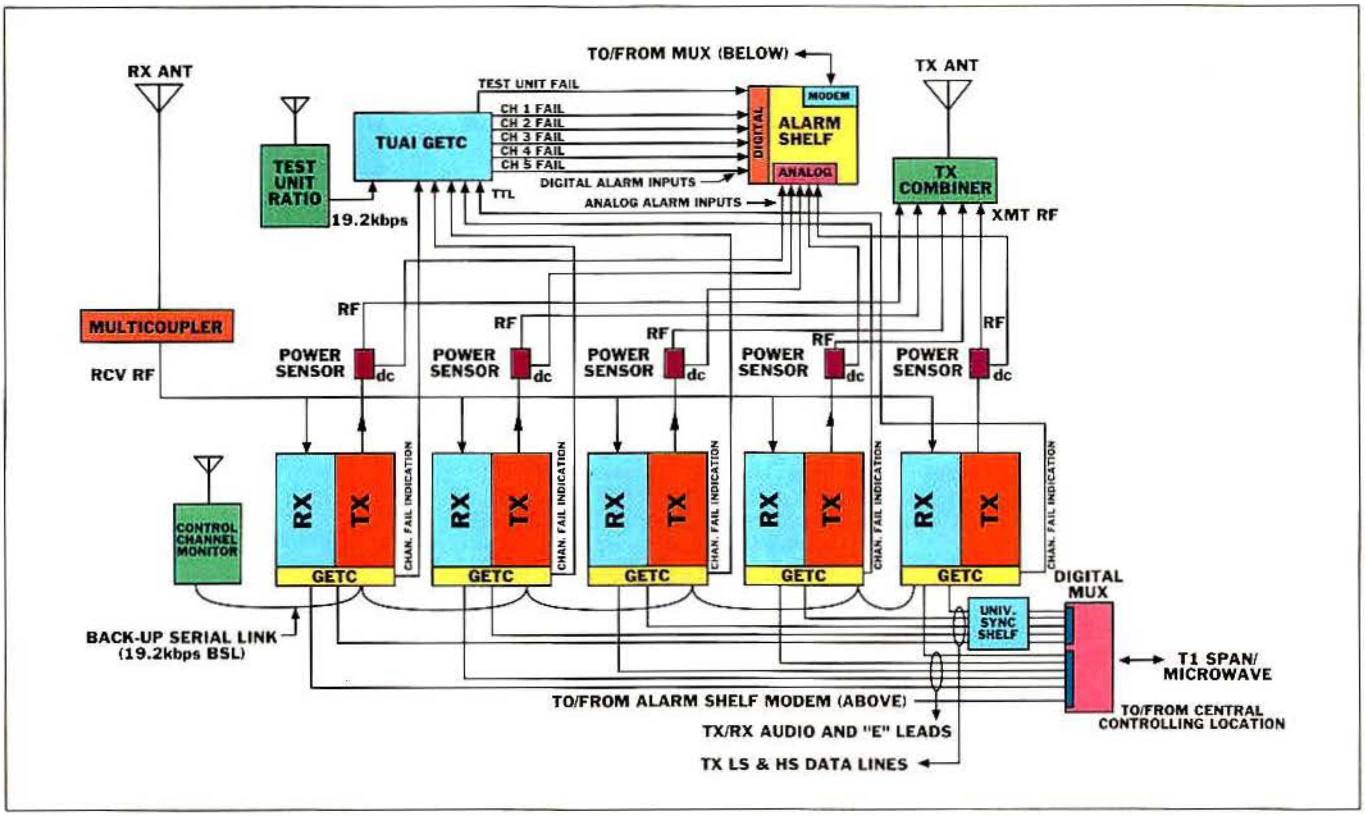

Figure 1. This equipment configuration is representative of an EDACS simulcast site with an automated test system and alarm shelf. Before being transmitted, the high-speed (HS) data must be synchronized in the universal sync shelf. Because the receive HS data does not need synchronization, the shelf is bypassed and connection can be made directly between the base station GETCs and the MUX. (The 300Hz and 2,400Hz sync tones as well as the low-speed [LS] data connections are not shown.)

The TU is the only radio in the system programmed to respond to a test call request. When the TU receives this request, it in turn requests a channel assignment (via an individual call). The site controller issues the channel assignment on the outbound control channel.

Once the TU receives this information, it informs the TUAI GETC (via the serial link) that the test process has begun. It lets the TUAI GETC know which channel is going to be used for the control and working channel. Equipped with this information, the TUAI GETC will be able to monitor its fault input lines from the proper radio channel.

The TU switches to the assigned working channel and listens for a high-speed (9600 baud) "dotting" signal to confirm that it landed on the proper RF channel. Once on the assigned working channel, the TU transmits a high-speed (HS) "keying" signal followed by constant low-speed (LS) data (150 baud).

The CCM also listens to the outbound control channel data. It outputs this received data onto the back-up serial link (BSL). The BSL is a 19.2kbps data buss that connects the GETCs of each RF channel together so each GETC knows what the others are doing. During a test call, the data from the CCM lets both the control and working channel GETCs involved in the test hear and respond to the test call request.

After receiving the TU's "keying" signal and LS data, the assigned working channel under test transmits LS data followed by a high-speed "drop channel" (dotting) message.

At this point, the TU sends its test results to the TUAI GETC and reverts to the control channel to monitor for future instructions.

This process tests the TU, the working channel receiver and transmitter, and the control channel.

If the working channel under test doesn't hear the proper HS or LS data from the TU, it sends a "fail" indication to the TUAI GETC. If the TU doesn't see the proper HS and LS data from the working channel, *it* will *also* send a "fail" message to the TUAI GETC. In this manner, both directions are tested: TU-to-working channel and working channel-to-TU. Both the working channel and the TU send their test results to the TUAI GETC. However, they are delivered in a different manner.

The TU sends its results as an RS-232, 19.2kbps serial bit stream. The TUAI GETC decodes the data into hex bytes that not only offer "pass" or "fail" information but also details relating to *what* in the test failed. For example, the TU can tell the TUAI GETC whether or not it heard a channel assignment on the outbound control channel, or whether there was a HS or LS data signal transmitted from the working channel under test. The TU can also tell the TUAI GETC whether or not the working channel ended the test properly with a high-speed "drop channel" message, or whether there may be a synthesizer unlocked on the control channel or working channel.

The working channel GETC, on the other hand, merely uses a single wire carrying either a TTL logic "high" or "low" to the TUAI GETC, offering only a "pass/fail" indication.

The CCM places the recovered outbound control channel data onto the BSL. This lets both the control channel and the working channel assigned to the test know *when* a test call request has been made. On receipt of this request, the normally "high" alarm line from the assigned working channel GETC goes "low." It returns "high" in less than one second if the test passes. If the test fails, the alarm line remains "low" and a "fail" indicator light should be activated on both the assigned working channel GETC and the TUAI GETC.

If either the TU or the working channel GETC indicate a "fail" condition, the TUAI

GETC sends the information along to the site alarm shelf as a "digital" alarm.

The alarm shelf's internal 1200/2400 baud modem can relay the alarm information back to a central controlling location via master/slave polling. There, it can be viewed on an alarm PC by maintenance personnel and passed on to the site controller. The site controller can be set up to automatically remove the failed channel(s) from service.

In addition to automated testing of the trunking functions that offer "digital" alarms, each transmitter at the trunking site may be equipped with an in-line RF power sensor. This sensor produces a dc voltage proportional to the RF level coming from the transmitter's PA. The voltage is applied to an input of an analog-to-digital converter card in the alarm shelf. These A/D cards convert the analog dc voltage to digital information that can be sent over the alarm shelf data modem back to a central location, resulting in the registration of "analog" alarms.

A detailed explanation of any EDACS configuration can quickly go beyond the scope of a magazine article. This description has been kept brief and basic but has offered an adequate glimpse into one of the features Ericsson employs within its simulcast EDACS trunking systems. ■

Maxtrac repeater combo

By Harold Kinley, C.E.T.

In the November 1990 issue of *MRT*, Carlton L. Tedrick, P.E., described how to link two Maxtrac mobile radios to serve as a link or repeater. In the May 1995 issue of *MRT*, William Plante, NCE, offered an improved version of the Tedrick design. In this issue, I offer you yet another version. This version is simpler to implement than the Plante design, yet sacrifices no features.

The old adage "Necessity is the mother of invention," is quite true. In this particular instance, several needs were met by combining two Maxtrac mobile units to serve as a portable repeater or communications *link*. Much of the design work was already done for me by the previous designs. It was only necessary to simplify the second design (Plante's design) to come up with the design that worked best for our situation in the South Carolina Forestry Commission.

We had procrastinated for some time about developing a portable repeater to help with communications during large forest fires where communications between handheld units was marginal. Other needs, such as a temporary spare repeater and a temporary communication link between state agencies on joint operations, spurred the development of this portable repeater.

Figure 1 below shows how the Maxtracs are modified and linked to form the repeater. The design by Plante in the May '95 issue of *MRT* required a transistor, two resistors and a switch per Maxtrac. This design requires only a diode and one resistor per Maxtrac along with a couple of simple jumper connections. The additional circuitry for the modification is shown in red.

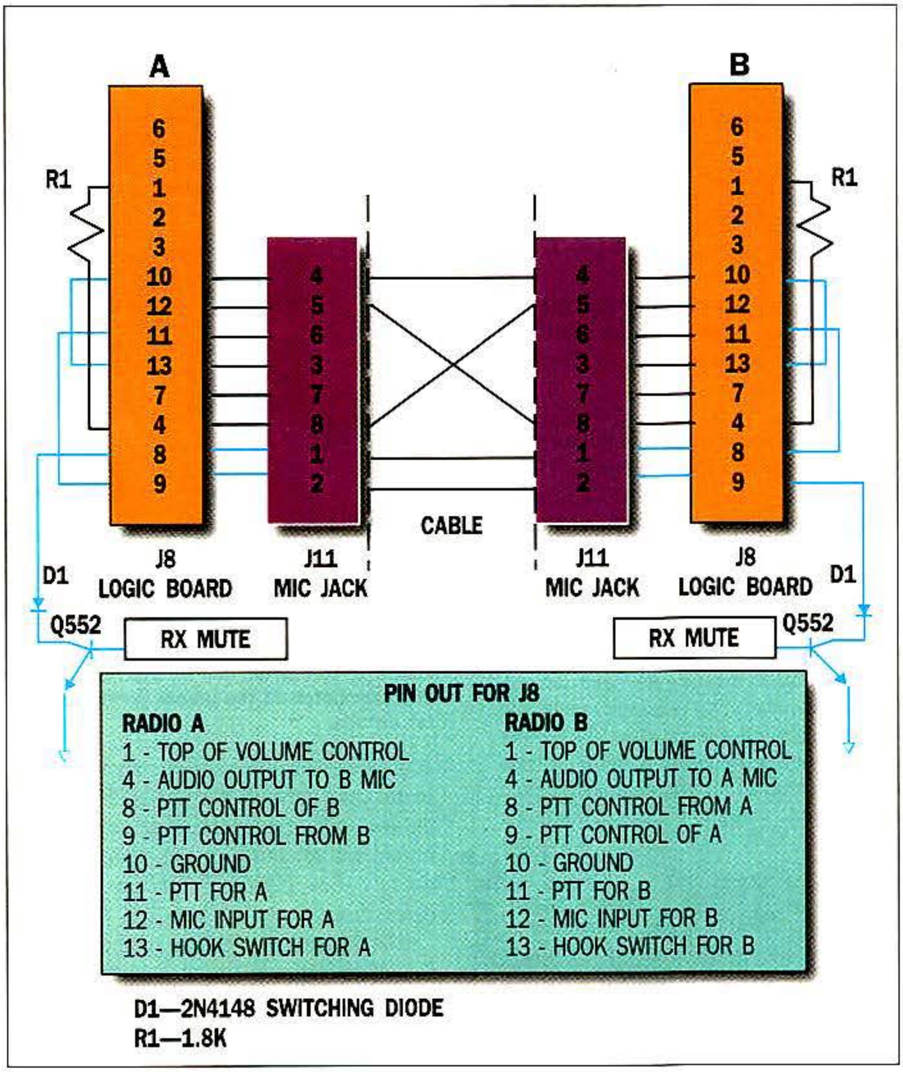

Figure 1. Wiring diagram showing how two Maxtracs are modified and interconnected to form a cross-band or in-band repeater.

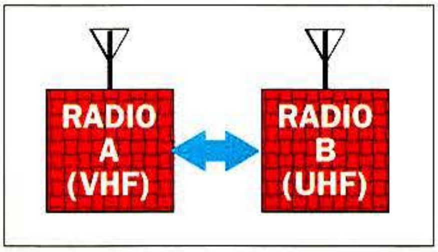

Figure 2. This setup forms a cross-band link between VHF and UHF radios. This is a bidirectional system. That is, each radio alternately operates in the transmit and receive mode.

To understand how the setup works, refer to Figure 1. A key point in the circuitry is the collector of transistor Q552. This is on the logic board of the Maxtrac and near the front, allowing easy connection of diode D1 from the collector of Q552 to pin 8 or 9 on J8. When the radio is not receiving a signal, the collector of Q552 is at +9.6V. Let's analyze the situation if radio A is receiving a proper signal. If a signal is received with the proper CTCSS (continuous tone coded squelch system) tone, Q552 is turned on placing the collector near ground potential. This turns on diode D1 which, through the interconnecting cable, places pin 11 of J8 on radio B (push-to-talk) at ground potential. This keys radio B. Audio from radio A (the receiver) passes from the volume control top through R1 (1.8K) and through the interconnecting cable to pin 12 (mic input) of J8 on radio B.

In this situation, radio A is the receiver, and radio B is the transmitter. The symmetrical arrangement allows for bi-directional operation. That is, radio B can become the receiver and radio A the transmitter. In certain situations this is desirable. But in some situations it is undesirable. Proper programming of the Maxtracs allows for great versatility in the repeater or link setup.

It isn't recommended, but the receiver can be operated using carrier squelch instead of CTCSS. The receiver can be programmed for carrier squelch, or the monitor button can be pressed to disable the CTCSS circuitry. Then the radio receiver will respond to any carrier on the channel. In this mode the collector of Q552 will go low on any on-channel signal—CTCSS or not.

The repeater or link can be operated several ways. The setup shown in Figure 2 on

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page 39 can be used to set up as a cross band link. Figure 3 at the right shows the setup as an in-band repeater. The duplexer that I selected is a mobile reject duplexer for the 150MHz band. It requires at least a 5MHz difference between receive and transmit frequencies. In our system, we receive at 151MHz and transmit at 159MHz, so this mobile duplexer works out fine for us.

A need arose where the South Carolina Forestry Commission and the South Carolina Department of Natural Resources needed to communicate on a joint operation. Since the DNR was operating at 151.xxxMHz and the SCFC was operating at 159.xxxMHz, the situation was ideal for the Maxtrac combo and duplexer. All that was required was to program the DNR frequency into one Maxtrac and the SCFC frequency into the other Maxtrac. Some tweaking of the duplexer provided good isolation between the two radios. With this arrangement connected to a short antenna, the two agencies could easily communicate—each using its own channel. The repeater setup was virtually transparent in operation. See Figure 4.

If you are using a duplexer for in-band operation, it is important that the duplexer is properly tuned to the operating frequencies for both radios. There will be a high side and a low side with a good frequency separation. In this case, the high side was at 159MHz and the low side at 151MHz. The key is to get maximum rejection at the undesired frequency. See Figure 5 for the following discussion.

The Maxtrac connected to the low-pass side of the duplexer (green) is operated at the lower frequency, in this case—151MHz. The Maxtrac connected to the high-pass side of the duplexer is operated at the higher frequency, in this case—159MHz. The low-pass

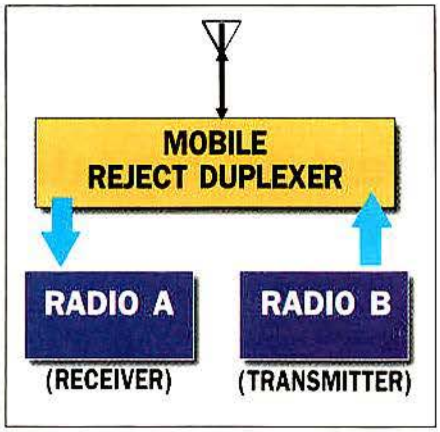

Figure 3. With this simple repeater setup one radio is receive-only while the other is transmit only.

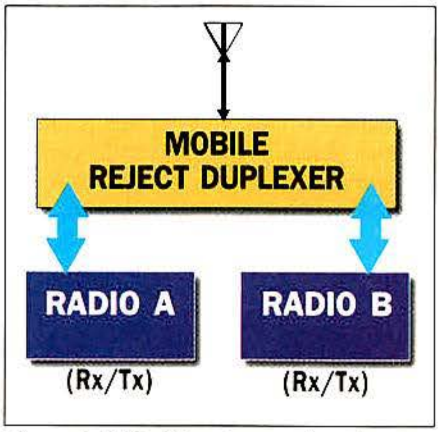

Figure 4. With this setup each radio alternately receives and transmits to serve as a link between units operating on different frequencies.

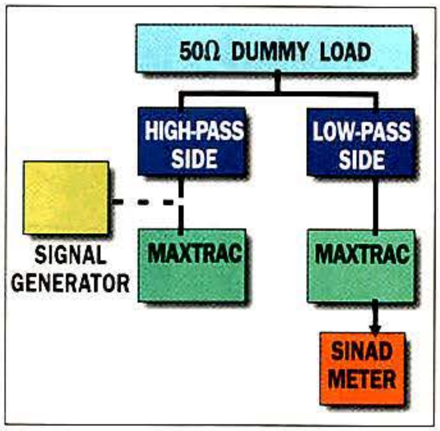

Figure 5. This setup can be used to tune the duplexer notch to the proper point. See text for details.

Photo 1. The portable repeater shown here is housed in a simple portable file box available from any office supply store.

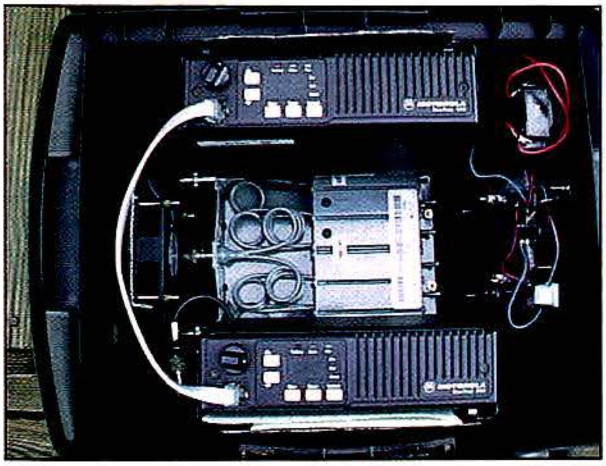

Photo 2. Inside view of the portable repeatrer box. The mobile duplexer is needed only for "in-band" repeaters.

side of the duplexer must be tuned to reject 159MHz. Thus, the Maxtrac connected to the low-pass side has a 159MHz frequency programmed into it to allow for tuning the notch. Simply set the Maxtrac to the 159MHz frequency, and set the signal generator to the same frequency. Adjust the tuning of the low-pass side of the duplexer for maximum rejection of the 159MHz signal as indicated on the SINAD meter. As the notch deepens, you will have to increase the level of the signal generator until you have adjusted the notch to maximum rejection of the 159MHz signal.

To tune the other side of the duplexer, you will have to reverse the connections shown here and tune the high-pass side for maximum rejection of a 151MHz signal. You would have to have the other Maxtrac programmed for a 151MHz frequency just for duplexer tuning purposes. The deeper the duplexer notches are tuned, the better the performance you will get from the repeater or link.

The modifications to the Maxtracs were done at the pins of J8, keeping the connections close to the board on the pins so as not to interfere with the connection of the plug, P8. Users should take extreme care to avoid solder bridges. The diode connected from the collector of Q552 to pin 8 or 9 on J8 should be enclosed in spaghetti tubing to avoid a possible short circuit with other components on the logic board.

To make the unit more convenient to handle, we used a portable file box to house the Maxtrac and duplexer combo along with the associated wiring. As shown in the photo, we installed a voltmeter, two fuses (one for each Maxtrac), an on/off switch, cigarette lighter socket, banana jacks/binding posts and a ventilation fan on the side panel of the file box. Two 12-volt ventilation (muffin) fans are used in a push-pull type operation so that sufficient air is flowing through the box at all times. A UHF connector is installed on the side of the box to allow easy connection to the external antenna. The portable repeater can be placed in a vehicle, connected to the vehicular antenna, powered from the cigarette lighter jack and serve as a temporary repeater wherever needed.

Until next time—*stay tuned!* ■

Small towns forego Project 25

Public safety agencies for some towns and cities with smaller populations are foregoing Project 25 interoperability because it is far more expensive than comparable alternatives.

Joe Beise, who works with the Wisconsin Public Service, said that he was concerned about the fact that Project 25-compliant technology was a great deal more expensive than other manufacturers' similar, non-compliant systems featuring technological advances made since the Project 25 specifications were created.

"The state of Wisconsin, about a year ago, was going to the Ericsson system that wasn't compliant, and it didn't seem to bother them too much," Beise said.

He also said that foregoing Project 25 compliant systems was becoming more and more frequent, especially in the less populated areas of the country, causing Project 25 to become a non-standard.

Craig Jorgensen, Project 25 project manager, said that he was not alarmed by the situation.

"If we were two years down the road I would have some concerns. But given the fact that Project 25 is a new technology, and given the fact that smaller agencies need to meet their budget, I don't think it's too much of a concern," he said.

Jorgensen also pointed out that this might change as the technology has been around longer.

"If you were looking two years down the road, and the standard had been out four years, then there would be some concern. But in a transition phase, you are going to see this kind of thing. I don't think it's that alarming," he said.

Beise suggested that part of the problem could be attributed to Motorola, because it seemed to have influenced the specifications to benefit itself.

"Motorola has weighted the standard to have about 75% of a compliant system to be only available from Motorola. They do give their licensing to other manufacturers, allowing them to use their patent to build competing radios—up to a point. If you were going to build a million-dollar system, you'd probably have to spend $750,000 with Motorola," he said, applying the digital radio standards, 12.5kHz bandwidth digital format, the Astro format.

"Project 25 might be able to find a home in places like Los Angeles, Denver and Houston—the big systems that are going to be multi-multi-million dollar systems. But a little sheriff's department shouldn't really care if their radio works in L.A. Should they pay $2,400 for a bulkier Project 25 radio rather than $800 for a very nice radio that fits their needs? What do they need it for?" Biese said.

If a few counties in one state opt to forego Project 25 and interoperability, it becomes pointless for the surrounding counties to be compliant. There is no one to be interoperable within the direct vicinity.

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READERS' CHOICE

Of the new products in the April 1998 issue, this one generated the biggest reader response. For more information on this product, circle the corresponding Fast Fact number on the card found in the back of this issue, and mail the card to us.

Counter tests radios anywhere

Optoelectronics' Techtoyz Micro Counter is housed in a pager-style case. The counter clips to a belt or will fit in a pocket. With a frequency range of 10MHz to 1.2GHz, the Micro Counter can lock onto a 5W UHF radio from as far away as 125 feet using the optional TMC100 rubber duck antenna. With an initial accuracy of 1ppm and a sensitivity level of <5mV, the Micro Counter is suitable for testing radios in the shop or in the field. Three selectable gate times are for increased resolution of the frequencies captured. The counter has four modes of operation: normal, filter, recall and digital auto capture.

Circle (500) on Fast Fact Card

Logic analyzers offer easy viewing

Hewlett-Packard has extended the performance range of its benchtop logic analyzers by introducing four flexibly priced series with flat-panel color displays. Color displays make traces of data, timing waveforms and analog signals much easier to view and to correlate. The flagship HP 1660ES series features a built-in, two-channel digital oscilloscope with integrated triggering and the ability to display analog signals with logic analyzer data. The scope offers 500MHz bandwidth, two-gigasamples-per-second sampling rate and 32K samples of memory. An integrated oscilloscope is most useful when both the triggering capability of a logic analyzer and the high resolution of an oscilloscope are needed to uncover tough hardware problems. For example, users can track elusive problems rapidly by viewing state, timing and analog information simultaneously on the analyzer screen using time-correlated markers.

Circle (401) on Fast Fact Card

Signal strength meter detects RF shadows

The Fox from **Berkeley Varitronics Systems** is a five-pound, hand-held, battery-powered meter. The models cover a wide range of frequencies. The meter measures RF propagation coverage and detects RF shadows. It is internally powered (or may be externally) and logs test measurements, or displays a wide assortment of built-in real-time macro measurements. These include follow mode, C/I, RSSI, adjacent channel, best server, peak hold, A-band or B-band scan and BER analysis. The meter features high measurement rate, internal eight-channel differential Global Positioning System (GPS) and fast charge circuit (<2 hours). There is a PCMCIA memory system for post processing data, capability to input X/Y coordinates from a floor plan and odometer input for correlation to distance during drive-around studies. Optional dead reckoning is also available.

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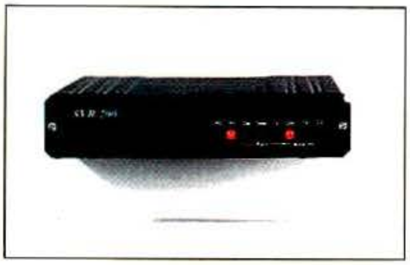


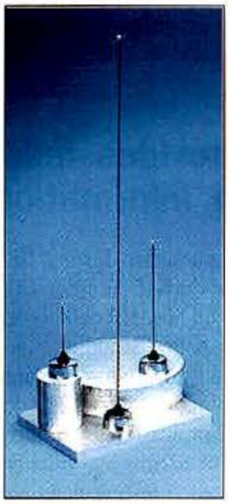
Repeater extends hand-held range

The SVR-200MA vehicular repeater from **Pyramid Communications** is available for UHF, VHF and 800MHz transmitters. The repeater extends the range of the hand-held radios by interfacing between a high-power mobile radio and a low-power hand-held, and is Motorola PAC/RT, LTR, EDACS and Motorola trunking compatible. The repeater features completely automatic operation and the ability to create a priority multi-unit hierarchy for as many as 256 vehicles. In addition, the unit offers "first man out" with priority sampling. This compact unit (5.275" × 6" × 1.12") offers benefits to public safety, paramedics, utilities and fleets by providing wide-area coverage without expensive satellite receivers, maintaining communications even inside buildings and eliminating the need for pagers and cell phones.

Circle (403) on Fast Fact Card

Antennas serve fleets, public safety

Larsen Electronics' low-cost, pre-tuned quarterwave antennas are for VHF, UHF and 800MHz/900MHz frequencies. This line is for fleet services and public safety. Each quarterwave antenna is manufactured with stainless steel whips, brass contacts and chrome-plated nuts for durability. All Larsen quarterwaves are backed by a three-year warranty.



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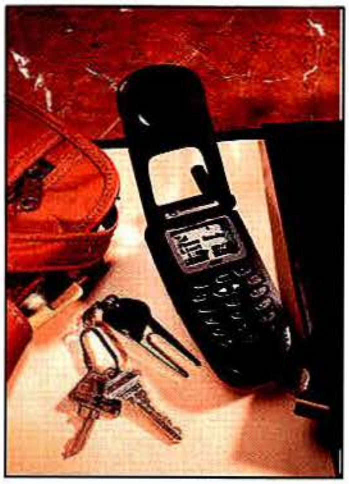
IDEN handset offers new features

Southern LINC is offering **Motorola**'s palm-sized i1000 IDEN handset. Small and light, this multiservice unit adds advanced features, such as speakerphone and caller ID, to existing capabilities including instant Linc (two-way radio), phone service and numeric and text paging. The new features of the handset include a small, contoured flip design weighing less than five ounces and a transparent window for viewing incoming calls and pages, scrolling through lists and making instant Linc calls without opening the handset. It has a built-in speakerphone and caller ID. It also offers a user-selectable, phone-only mode for users to detach themselves temporarily from their workgroups during meetings and non-working hours. The name and number display of stored phone and instant Linc numbers shows the name and the associated number together.



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Crystals meet low phase noise apps

International Crystal Manufacturing's specialty crystals have tight calibration tolerances, temperature tolerances, resistance tolerances, shock and vibration and phase jitter requirements. ICM produces thru-hole packaged specialty crystals. The TO-5 (HC-35) crystal has a range of 10MHz–180MHz, specified at series resonances and optional temperatures of 25°C or 75°C. The TO-5, with a standard lead length of 0.5", is mounted at two, three or four points for superior shock and vibration performance. Although these crystals are specified at series resonances of 25W–100W and operational temperatures of 25°C or 75°C, they can be manufactured to meet other values if the requirements are specified when the order is placed.

Circle (406) on Fast Fact Card

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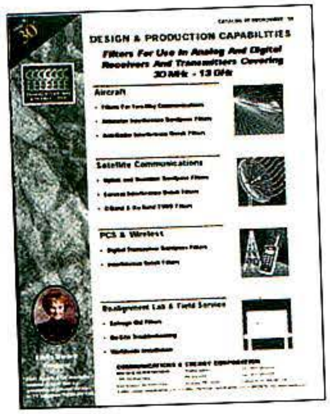
Brochure features capabilities for microwave, RF communications

Communications & Energy has released a capabilities brochure for microwave and RF communications. The 11-page brochure contains a description for C&E's design, engineering, production, repair, realignment, field service, printing and publishing capabilities. It also contains a synopsis of the organization's history, markets and customers. A cross-sectional sample of products are pictured in the brochure as examples of the kinds of products that the organization has designed and produced. The brochure contains a fax-back inquiry form for either requesting a quotation on a custom product or ordering the company's catalogs of standard products.



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Second-edition reference manual assists telecom engineers

The second edition of the *Reference Manual for Telecommunications Engineering*, now revised, updated and expanded, incorporates all of the changes that have taken place in the industry. The manual, published by **John Wiley and Sons,** continues to provide the latest information on designing, building, purchasing, operating and maintaining telecommunications systems of all kinds. The reference, consisting of over 2,300 pages, features tables, graphs, figures, formulas, nomograms, statistics, standards and regulatory information that telecommunications engineers must know, use and apply in their day-to-day work. Information is broken down into 31 subject areas designed for instant access and application. To help users retrieve data, the book provides an index, a listing of acronyms and abbreviations as well as extensive cross referencing.

Circle (452) on Fast Fact Card

Publication provides uninterruptible power testing information

Hewlett-Packard has published *Testing Uninterruptible Power Supplies with Hewlett-Packard AC Sources* This publication is free and provides information on how HP 6800 series ac power sources/analyzers can be used to help test uninterruptible power supplies (UPS) in many environments, including research and development, manufacturing and incoming inspection. The document is designed to help engineers and test professionals simplify their characterizations and testing of control circuits and final product performance. It explains how HP ac source testing determines if a UPS is designed and operating properly, which will help ensure the satisfactory protection of sensitive equipment against ac mains voltage abnormalities.

Circle (453) on Fast Fact Card

people

Jasin

Hillard

Engle

Ackzen

Mark Jasin departs Ritron, Carmel, IN, as national sales manager to become Midwest regional sales manager for Kenwood Communications, Long Beach, CA.

James C. Hillard, leaves the American Society of Association Executives, Washington, DC, as manager of the technology section and educational programs to become institute director for APCO–International, South Daytona, FL.

Michael C. Engle, leaves Microwave Networks, a division of California Microwave, Redwood City, CA, as vice president of marketing and customer support to become vice president of international sales for Tadiran Microwave Networks, Houston.

Motorola and the executive board of the Motorola Trunked Users Group (MTUG) presents the *Danny Smith Award* to **Brent Ackzen**, a bureau commander in the Glendale, AZ, police department and MTUG southwest regional director. The award recognizes individuals who have shown outstanding leadership and service to MTUG.

Craig F. Szczutkowski leaves Ericsson Private Radio Systems, Lynchburg, VA, as vice president of international business to become senior vice president of product and market development for Transcrypt International, Lincoln, NE.

Robert Ripp, executive vice president of AMP, Harrisburg, PA, advances to chief executive officer.

Pamela Morais leaves Atlantic Cellular, Providence, RI, as vice president of human resources to become vice president of human resources for Crown Communications, Pittsburgh, PA.

Holmes Bailey, president of ECI, Rutherford, NJ, becomes general manager for Berkeley Varitronics Systems, Metuchen, NJ.

Ron Brann leaves Cabletron Systems, Rochester, NH, as international sales manager to become international account manger at Gabriel Electronics, Scarborough, ME.

Changes at Intek Global, Princeton, NJ:

Howard Frank, dean of the Robert H. Smith School of Business at the University of Maryland, will serve on the audit committee of Intek's board of outside directors. **Eli M. Noam**, senior faculty member in the Finance and Economics Department at Columbia University Graduate School of Business and Director of the Columbia Institute for Tele-Information, will serve on the compensation committee, also of the board of outside directors.

William H. Cole moves up from director of business development to president of Airtech Wireless, Carrollton, TX.

Bruce Bishop, vice president of engineering at TECOM, Chatsworth, CA, becomes the company's president.

Tony Gutierrez leaves BK Radio/RELM Communications, Melbourne, FL, as international sales director to become director of sales for RF Industries, San Diego.

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Don Bishop EDITORIAL DIRECTOR
Date: SEPT 14, 1998

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employment

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MOTOROLA portable MT-500 model H34BBU3184A 450-470 range, 8 freq., w/battery & antenna	$35
MOTOROLA local controls model T1370A	$12
GE MPD portable w/accessories, band 150-170 range w/voiceguard	$225
GE DELTA S or SX Mobile—110w, hi-band 150-170 range w/accessories	$200
GE MPS Portables synthesized version of MPX high band with battery	$65
GE DELTA tabletop base 40 watt UHF 450-470 range	$300
GE MARC V SRM trunked repeater 800 MHz range, less duplexer & cabinet	$750
GE PHOENIX Mobile NSHH1W40TB—Hi-band dual priority scan/grey case with accessories	$200 ea.
GE PCS portable hi-band 150-170 range w/scan	$225
GE TMX 8310 mobiles 800 MHz range w/accessories	$65
GE CMX 8630 mobiles 800 MHz range w/accessories	$85
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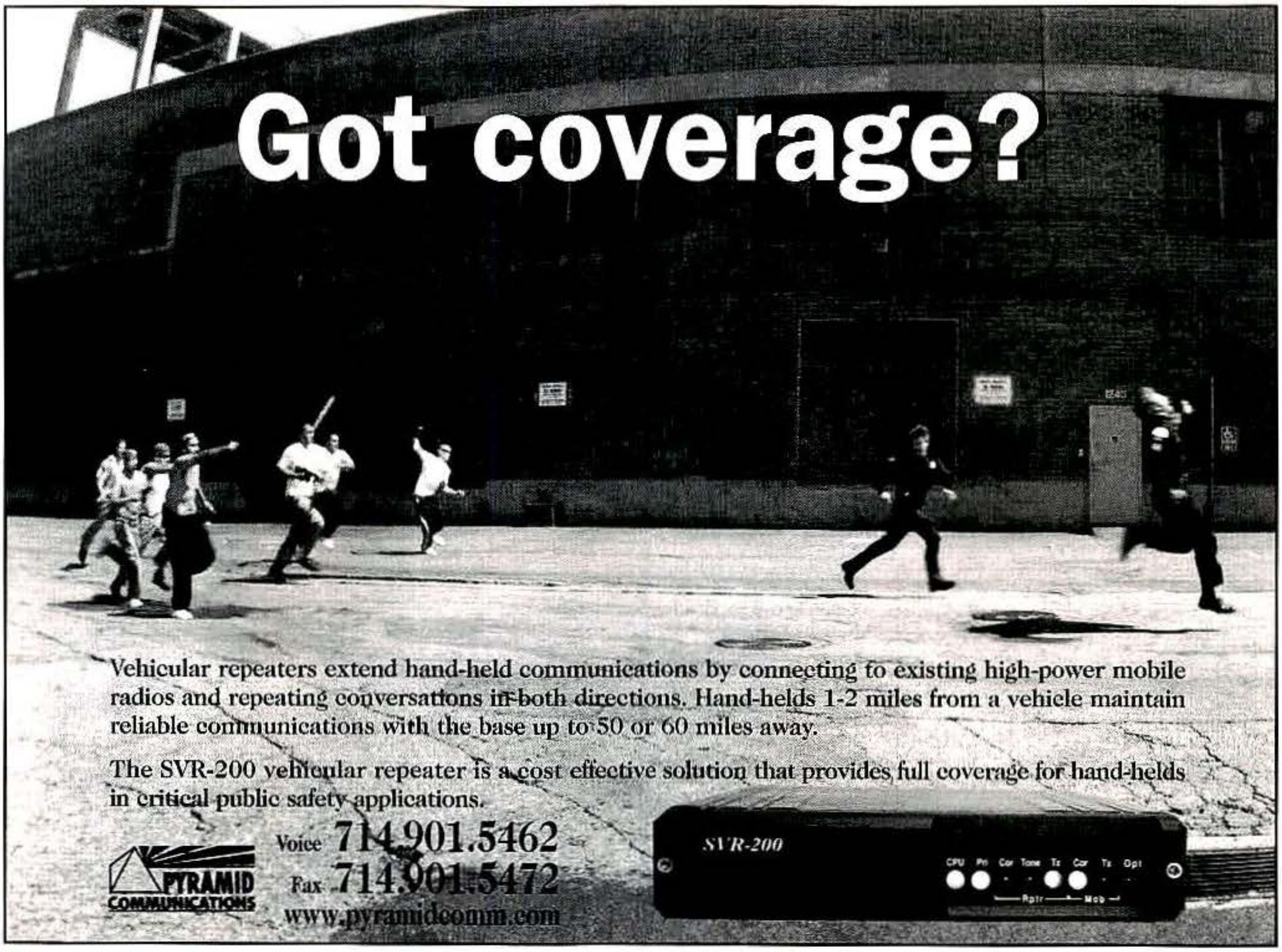

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675	Maxon TPA-1125 Rapid desktop charger	$20 ea.
1448	Maxon TPA-1120 Std. Rate Pedestal Charger	$5 ea.
1	Maxon TPA-1160 Battery-Maxon TP4800 Portable	$5
1750	Maxon TPA1120x Charger w/TP4800 Portables	$5 ea.
1000	EF Johnson EJF8605Lit Literature	make offer
3	EF Johnson EFJ0235800017 RPI to computer cable	$10 ea.
1	EF Johnson EFJ0239998192 Programming software	$50
100	Standard CNB584A Battery Hi-Cap for HX581	$40 ea.
97	Standard CSAS81A Desktop rapid charger for HX581	$30 ea.
50	Ant-Specl ASP-KAV383 Re-install kits on glass	$10 ea.
20	Motorola MSF-5000 800 conv 15 800T 75w	
10	Motorola MSF-5000 900T	
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6 ea. MASTR II Rptr., 460MHz, SC65VAU888
1 ea. MICOR Comm. Rptr., 460MHz, C64RCB3105AY
2 ea. MICOR Bases, 460MHz, C64RCB1105AT
71 ea. SYNTOR X 9000, 460MHz, T34KEJ7J04AK
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33 ea. MITREK, 460MHz, T44JJA6000
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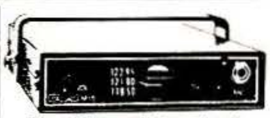

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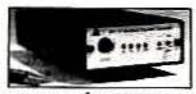

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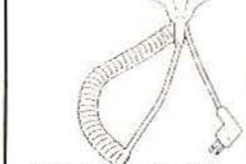

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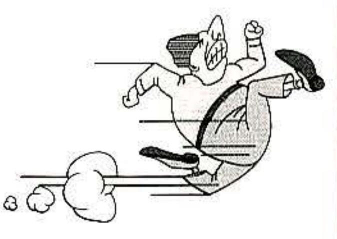

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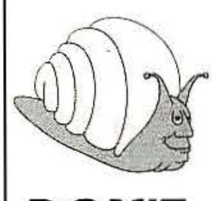

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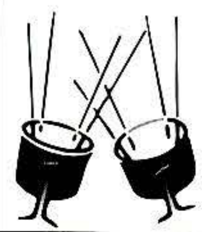

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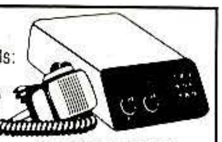

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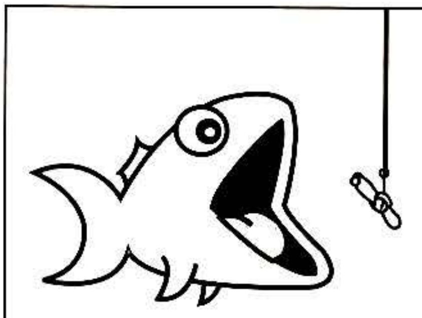

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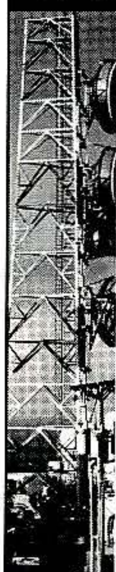

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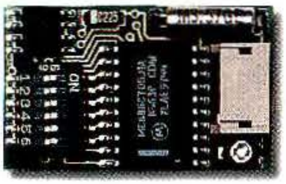
Communications Data Services	61	119	800-441-0034
Computer Resources Inc.	61	121	205-987-1523
Comtelco Industries Inc.	44	46	800-634-4622
Control Signal Corp.	42	44	800-521-2203
CPI Communications Inc.	38	39	972-437-5320
Crystronics, Inc.	60	117	954-491-9501
Daniels Electronics	34	30	604-382-8268
DAPA Communications, Inc.	5	17	716-373-7228
Doppler Systems, Inc.	47	36	602-488-9755
DX Radio Systems	30	14	213-257-0800
EAGLE	26	26	520-204-2597
EDX Engineering, Inc.	37	38	541-345-0019
El Paso Communication Systems	58	114	915-533-5119
Eupen Cable USA	20	12	813-527-7955
The Genesis Group	60	118	903-561-6673
Glentech	55	107	847-891-2584
Holaday Industries, Inc.	46	34	612-934-4920
Hubersuhner AG	25	25	+41 (0) 71 353 41 11
IFR Americas, Inc.	IFC	1	316-522-4981
International Crystal Mfg.	38	40	405-236-3741
J.E.I.	47	37	916-677-3210
Kantronics	59	115	785-842-7745
Kenwood Communications	7	18	800-950-5005

Company	Page Number	Fast Fact Number	Advertiser Hotline
Klein Electronics	56	111	760-631-2811
Marketronics Corp.	31	15	800-845-1230
McManus Communications	56	109	870-763-6250
Mechem Electronics	56	110	540-891-0569
Micropath Corp.	61		303-526-5454
Motorola Test Equipment	15	8	800-505-TEST
Narda/L3 Communications	43	45	516-231-1700
New Hampshire Communications	56	108	603-668-3004
Norcomm Corp.	48	47	916-477-8400
PageCorp Industries	60	116	800-957-8700
Paging & Wireless Service Center	52	100	561-683-0022
Polaris Industries	57	112	404-872-0722
Polyphaser Corp.	35	32	800-325-7170
Pyramid Communications	54	105	714-901-5462
Radio Express, Inc.	57	113	800-545-7748
RCC Consultants	63	123	732-404-2400
RCW Distributing	52	101	800-726-9015
RSI	63	124	316-825-4600
Selectone	32	16	510-781-5432
Sharp Communication	52	102	800-548-2484
Shinwa Communications of America	41	42	800-627-4722
SoftWright	61	120	303-344-5486
Swager Communications	62	122	800-968-5601
Telepath	45	33	510-656-5600
Thunder Eagle	34	31	703-242-0122
Transcrypt International	1	4	800-894-2609
Trident Micro Systems	29	13	800-798-7881
Trilogy Communications Inc.	13	6	601-932-4461
Tripp Lite	14	7	312-755-8741
TX RX Systems Inc.	3	5	716-549-4700
Vega, A Mark IV Company	10	20	626-442-0782
VERTEX/YAESU USA	23	23	310-404-2700
Vocom Products Co. LLC	41	43	800-USA-MADE
WETEC Electronics	55	106	901-286-6275
Zetron Inc.	IBC	2	425-820-6363
Zetron Inc.	21	22	425-820-6363

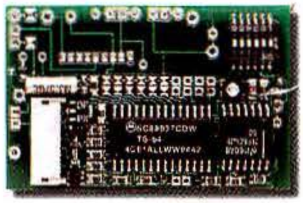


SS-64 — **$28.95**

Microminiature DIP Switch Programmable CTCSS Encoder.
Includes 64 tones from 33.0 to 254.1 Hz.
.66" x 1.08" x .21"

TS-64 — **$54.95**

Sub-miniature Programmable CTCSS Encoder-Decoder.
Includes 64 tones from 33.0 to 254.1 Hz.
.78" x 1.70" x .25"



TS-64DS — **$57.95**

DIP Switch Programmable CTCSS Encoder-Decoder.
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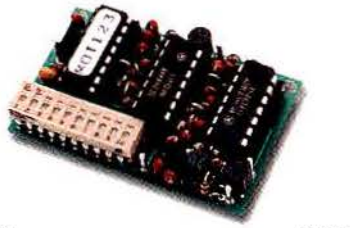
Full Featured Shared Repeater Tone Panel with ALL 157 CTCSS/DCS codes. In Desktop or Rack Mount versions.

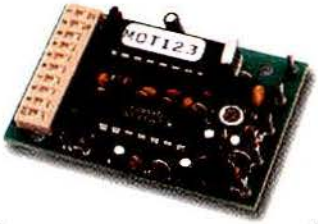
PE-1000 — **$224.95**

Desktop Paging Encoder. Two-Tone Sequential, other formats available. 7.5" x 7.8" x 2.7"



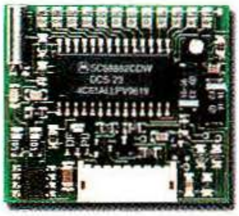
SD-1000 — **$59.95**

Two-Tone Sequential Decoder. Programmable unit provides switched outputs from Two-Tone paging calls.
1.25" x 2.0" x .4"



PE-2P — **$54.95**

Two-Tone Sequential Encoder. Sub-assembly mounts inside radio or other enclosure. Multiple call capability.
1.25" x 2.0" x .4"

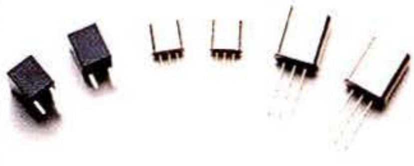


DCS-23 — **$59.95**

Digital Coded Squelch Encoder-Decoder. Programmable to all 106 DCS codes. 1.36" x 1.18" x .25"

TE-64D — **$129.90**

Multi-Purpose CTCSS/Burst Tone Encoder w/LED Display. Great for the Benchtop. 5.25" x 3.3" x 1.7"



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